ORIGINAL MEMOIRS.

THE INTRA-ABDOMINAL ADMINISTRATION OF OXYGEN.

A FURTHER CONTRIBUTION, WITH REPORTS OF ADDITIONAL CASES.*

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IN a previous communication [1] I endeavored to give, as briefly as possible, a *résumé* of the medical and surgical uses of oxygen, tracing the therapeutic history of the gas from the time of its discovery to the present day.

In reviewing the literature of the subject I touched briefly upon what has been accomplished with the gas by *inhalation* in various conditions, by *subcutaneous injections*, by *intravenous infusion*, in *obstetrics*, in *children's diseases*, in *gynæcology*, in *general therapeutics*, and in *surgery*.

Following this I reported a series of sixteen cases in which oxygen had been employed intra-abdominally according to the method detailed below. These cases were selected from a number in which the gas had been administered in various ways in my services at the New York City Children's Hos-

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[1] "Oxygen in Medicine and Surgery—A Contribution with Report of Cases," *New York State Journal of Medicine*, June, 1908.

pitals and Schools, the New York Skin and Cancer Hospital, and the New York Polyclinic Medical School and Hospital, as well as in private practice.

The clinical experience from which these cases were drawn was chiefly surgical, and extended over a period of about five years, during which time the gas was employed in the following ways: (1) by *inhalation;* (2) by *infusion into the pleural cavity;* (3) by *injection into abscess cavities, carbuncles, furuncles,* and other inflammations, acute and chronic; (4) by *injection into tuberculous joints;* (5) by *infusion into the abdominal cavity,* allowing the gas to be gradually absorbed, in the following conditions: (*a*) tuberculous peritonitis, with ascites; (*b*) after removal of ascitic fluid from whatever cause; (*c*) following severe laparotomies, for the control of shock, for its influence upon hemorrhage, cyanosis, nausea, and vomiting, and for the prevention of adhesions.

ANIMAL EXPERIMENTATION.

In the paper to which reference has been made I also reported animal experiments, which were conducted for the purpose of determining to what extent clinical deductions were capable of verification by laboratory methods. In the conduct of those experiments I received the valuable assistance of Dr. Harold Denman Meeker, Dr. James T. Gwathmey, and Dr. D. R. Lucas.

The work was executed with the following definite objects in view:

1. To determine the absorbability of oxygen.

2. To determine its effect upon (*a*) blood-pressure, (*b*) pulse, (*c*) respiration, (*d*) degree of anæsthesia, (*e*) time of recovery after anæsthesia.

3. To effect a comparison between the results upon the above when oxygen is employed and when air is employed.

4. To determine the danger-point of intra-abdominal pressure as manifested by a fall in blood-pressure, respiratory embarrassment, and cardiac failure.

5. To determine the effect of oxygen upon adhesions in the abdominal cavity.

From these experiments the following deductions were made:

(1) Oxygen is completely absorbed in the abdominal cavity. (2) It is a slight respiratory stimulant. (3) It is a slight cardiac stimulant. (4) It has but little effect upon blood-pressure when the pressure of the gas is moderate. (5) It tends to bring an animal quickly from deep anæsthesia. (6) It hastens the recovery of an animal after discontinuance of the anæsthetic. (7) A pressure of more than 1500 mm. of water may cause collapse. (8) Oxygen tends to prevent the formation of adhesions. (9) It quickly changes a dark blood to scarlet in cases of anoxæmia. (10) It stimulates intestinal peristalsis. (11) It is not an irritant to the peritoneum or abdominal viscera.

While the conclusions drawn from the experiments reported in my previous paper have not been in accord, in every instance, with those reached by other workers from similar investigations, in no case have the discrepancies seemed of sufficient importance to warrant a change of view with reference to the possible clinical value of this application of oxygen. Therefore, since the publication of the paper referred to above, I have continued to test the utility of the intra-abdominal administration of oxygen wherever it seemed to be indicated. In this research the field of usefulness has gradually enlarged, as I shall presently show. It is now administered for the following purposes:

1. To lessen shock, hemorrhage, nausea, and vomiting.

2. To overcome negative intra-abdominal pressure after removal of large tumors.

3. To prevent the formation of adhesions.

4. For its effect upon tuberculous peritonitis of certain types.

5. For its effect upon pus-producing organisms and their toxins.

METHOD OF ADMINISTRATION.

In the abdominal administration of oxygen I have em-

ployed the so-called pure gas.*   The gas is warmed, usually
to a temperature of from 90°-100° F.   This is accomplished
by passing it through a rubber tube from the tank in which
it is compressed into a wash-bottle filled with hot water. From
this bottle the partially warmed gas passes through the exit
tube, which is coiled in a basin of hot water.   This long exit
tube is again connected with a piece of glass tubing, and to
this, in turn, is attached a piece of sterile rubber tubing
through which the gas is introduced into the abdominal cavity.
In this last piece of tubing, at the distal extremity, are two
openings, one in the end, which is cut off obliquely, and the
other in the wall of the tube, near the end.

Instead of the rubber coil in the basin of hot water, a
Leiter's coil, or a special metal coil which will allow of the
heating of the oxygen, may be employed.

The abdominal wound is closed, except at the lower or
upper end, as the case may be, where the free end of the
tube is placed within the abdominal cavity.   One stitch is
introduced above and one below the tube, and these are tied.
An interrupted stitch is placed in the peritoneum at this
point, ready to be tied, and a purse-string suture is introduced
around the tube in the peritoneum, left long but not tied.
All layers of the abdominal wall are closed, up to the skin,
and the stitches tied, with the exception of those in juxta-
position to the tube.   These, layer by layer, are tied after
the purse-string stitch has been fastened.

When the desired amount of gas has been introduced the
tube is carefully withdrawn and the purse-string stitch tied,
all the others being then fastened layer by layer. Care should
be taken, of course, to prevent intracellular emphysema, which,
while not harmful, may be a source of some discomfort to
the patient.

The amount of oxygen to be administered depends upon

* The gas which I now employ has been shown by analysis to contain
from 94.3 per cent. to 97 per cent. oxygen; 2.37 per cent. to 4.5 per cent.
nitrogen; a trace of carbon dioxide; no chlorine; no nitrous oxide. Simi-
lar relative purity of the gas used should be insisted upon by the surgeon.

the exigencies of the case. Where there is abdominal distention from ascites or tumor, the girth of the abdomen should be measured before operation, and after removal of the fluid or the tumor the abdomen should be distended to the same or perhaps a little less degree by the admission of oxygen. Where there is no distention of the abdomen a crude yet practical test in the average case is found by first determining that the liver is not adherent to the chest wall and is of approximately normal size, then administering enough oxygen to obliterate liver dulness. A gauge such as is used in measuring the amount of oxygen in animal experiments may be employed.

So far as I have been able to ascertain from a careful review of the literature of the subject, the intra-abdominal administration of oxygen where the gas is allowed to remain *in situ* until absorbed, had not been employed previous to my own work in this line. With the use of oxygen in its nascent state, as in hydrogen peroxide, all are familiar. Thiriar and others have employed the gas in a continuous stream, thus flushing out the abdominal cavity after laparotomies and after evacuation of ascitic fluid in tuberculous peritonitis. The application of the gas in this manner is made with a view of stimulating the tissues, preventing the extension of the inflammation, causing increased phagocytosis and leucocytosis, destroying the germs or diminishing their virulence, neutralizing their toxins, and " substituting an oxygenated emphysema for the microbian emphysema." The gas is introduced in a continuous stream, 40 to 50 litres of oxygen being used at one treatment, always with a free outlet.

In the cases detailed in my previous communication, and in those which I shall now report, the abdomen was ballooned with the gas and the wound carefully closed, according to the method which I have described, the oxygen being allowed to be absorbed gradually by the tissues. In the cases of abdominal distention with ascitic fluid, in certain forms of tuberculous peritonitis, and in some cases where large tumors were removed, the gas was introduced, as previously

stated, to the point of distention caused by the fluid or by the tumor.

In this manner the negative intra-abdominal pressure which follows the removal of fluid or tumors is overcome by a means which gradually and imperceptibly to the patient lessens the pressure, at the same time distending the necessarily torn and bruised tissues until such time as there is very little danger of the formation of adhesions. This, it seems to me, is better than the pressure-pads so often used.

In cases where there is no undue abdominal distention by the pathological process, and yet where the surgical intervention is such as to entail the possibility of severe shock or extensive capillary hemorrhage, with subsequent nausea, vomiting, and abdominal tenderness, oxygen is introduced to the point of removal of all liver dulness, or according to the exigencies of the case.

Thus, in addition to whatever phagocytic and bactericidal action the oxygen may exert, we have a lessening of shock, a control of hemorrhage from small vessels, a decrease of cyanosis, an early improvement of the pulse and respiration, and in many instances such response to the oxygen stimulus that more anæsthetic is necessary in order to keep the patient anæsthetized until the completion of the operation. As a rule, the nausea, vomiting, and abdominal tenderness which so often follow severe operations are much less than one may reasonably expect.

The following additional cases admirably illustrate the action of the oxygen in the manner just described. While some of the cases were of such nature that there is reason to believe recovery would have taken place in any event, the oxygen merely acting as a temporary stimulant, in others the condition of the patient at the time of operation was so bad, or the shock from the operation was so great, that the result without some such support as oxygen seemed to give would have been questionable.[2]

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[2] For report of cases I to XVI, inclusive, see *New York State Journal of Medicine*, June, 1908.

CASE XVII.—A. C., female, aged 44, married, laundress. Prolapsus uteri. Operation, April 2, 1908, divulsion, curettage, appendectomy, suspension of uterus. Condition very poor. Pulse and respiration immediately improved upon the intra-abdominal administration of oxygen, and more anæsthetic had to be given. Recovery uneventful.

CASE XVIII.—G. V., male, aged 51. Seen in consultation with Dr. Henry Franciscus, of Brooklyn, April 24, 1908. Admitted to the New York Skin and Cancer Hospital, April 28, 1908. Irremovable gastric and intestinal carcinoma. Operation May 4. Gastro-enterostomy performed. The patient's general condition was very poor, and the shock from the operation was so great that he came near dying on the table. He rallied, however, as soon as oxygen was introduced into the abdomen. The wound healed by primary union, and the patient did as well as could be expected for three or four days, but coincidental with the total absorption of the oxygen he began rapidly to lose ground, and died, May 11. Postmortem revealed the fact that all of the gas had been taken up by the general system, and that there remained no changes in the peritoneum which could be attributable to the action of the oxygen.

CASE XIX.—J. B., female, aged 38, married, housewife. Endometritis, both ovaries cystic. Operation May 7, 1908. Divulsion and curettage. Left ovary removed; multiple punctures in right ovary; appendectomy. Oxygen administered intra-abdominally exerted a stimulating effect which was distinctly observable. Abdominal tenderness following the operation was less marked than is usual in such cases. Recovery uneventful.

CASE XX.—G. P., female, aged 39, married. Seen in consultation with Dr. M. W. Barnum, of Ossining. Ovarian cyst. Operation at the Ossining Hospital May 16, 1908. Left ovarian cyst weighing six pounds with beginning cancerous degeneration removed; right ovary, also diseased, removed; appendectomy. Shock considerable. The introduction of oxygen caused immediate improvement in the patient's condition. Recovery uneventful.

CASE XXI.—S. A., female. Chronic appendicitis, with many peritoneal adhesions. Operation May 23, 1908. Adhesions broken up and appendix removed. Oxygen administered in this case chiefly with a view to preventing the formation of adhesions.

Recovery was uneventful, and subsequent history has revealed nothing that could be attributed to the return of adhesions, despite the chronic nature of the condition.

CASE XXII.—S. B., male, aged 26. Carcinoma involving omentum, peritoneum, and intestines. Operation, New York Skin and Cancer Hospital, June 4, 1908. The general condition of the patient was so bad and the disease so extensive that nothing more than exploratory laparotomy could be done. Oxygen was introduced, and in a few minutes the patient came out of the anæsthetic and made vigorous attempts to get off the operating table.

CASE XXIII.—D. H., male, aged 35. Admitted to the New York Polyclinic Medical School and Hospital, June 19, 1908. Abdominal distention of six months' duration. Had been previously tapped six times. Refused Talma's operation for cirrhotic liver. Fluid withdrawn under local cocaine anæsthesia and oxygen administered. Patient said he was "buoyed up" by the oxygen and felt better after this than he had for a long time. He noticed a difference in his feelings on this and previous tappings. He insisted upon returning to his home in Florida next day. Oxygen, while diminishing, was still present in the abdomen.

CASE XXIV.—C. E., female, aged 22, married, housewife. Admitted to the New York Skin and Cancer Hospital, June 10, 1908. Extra-uterine pregnancy, ovarian cyst, pelvic peritonitis. Extra-uterine pregnancy, right tube and right ovary removed. Many adhesions around the appendix broken up and appendectomy performed. Oxygen was introduced intra-abdominally. The patient's condition improved at once, her color became better, breathing easier, pulse fuller and slower, and the patient came out quickly from the anæsthetic. Recovery uneventful.

CASE XXV.—M. D. S., female, aged 33, single. Admitted to the Alston Sanitarium June 24, 1908. Fibromyoma of uterus. Operation June 26. Removal of tumor weighing six pounds; right tube and ovary removed; extensive adhesions broken up. Shock very great. Immediately upon the introduction of oxygen into the abdomen the condition of the pulse and respiration improved. There was slight postoperative vomiting, practically no nausea, and very little abdominal soreness. Appetite good immediately following the operation; all food retained. Recovery uneventful.

CASE XXVI.—R. J., female, aged 30, single, teacher. Retropoised uterus; pelvic peritonitis; chronic appendicitis. Operation, Jamestown Hospital, Jamestown, N. Y., July 12, 1908. Many adhesions around the appendix broken up; appendectomy; uterus suspended. Considerable shock, which was promptly overcome by the intra-abdominal administration of oxygen. Recovery uneventful.

CASE XXVII.—W. E., female, aged 68, married. Referred by Dr. H. T. Wolf, of Yonkers. Abdominal carcinosis, kinking of the gut, with intestinal obstruction. Operation April 14, 1908, at St. John's Riverside Hospital, Yonkers, assisted by Dr. Getty and Dr. John, of the attending staff. The case was so extreme that operative procedure was warrantable only upon the ground of attempting to control the vomiting, which was almost fecal in character. A large amount of fluid was removed from the abdomen, and the intestine straightened. Adhesions around the left ovary broken up and the ovary removed. The patient was practically pulseless. The intra-abdominal administration of oxygen was followed by prompt improvement in pulse, respiration, and general condition. The patient rallied from the operation. There was no subsequent vomiting, except just before her demise. The bowels moved easily, and it would seem that the patient did as well as could be expected so long as the oxygen was in the abdomen, but when this was all absorbed she succumbed from asthenia, four days after operation.

CASE XXVIII.—F. W., female, aged 37, married, housewife. Referred by Dr. William W. Van Valzah. Anæmia, hemorrhoids, chronic appendicitis; left ovary prolapsed and cystic; uterus retroverted and large; many abdominal adhesions. Operation, Woman's Hospital, June 3, 1908. Curettage; modified Gilliam; adhesions broken up; appendix removed; left ovary removed. Considerable shock. Condition perceptibly improved upon the introduction of oxygen and remained good. Recovery uneventful.

CASE XXIX.—R. V., aged 29, female, married, housewife. Exploratory laparotomy, June 12, 1907, at the New York Skin and Cancer Hospital. Papillomatous degeneration of uterus, tubes, and ovaries found, extending to the intestines and well up toward the liver. A detached portion was removed for microscopic examination, the report being "malignant papilloma." Ten days later panhysterectomy was performed and a large

amount of fluid evacuated. A large papillomatous mass in the pelvis was also removed. On November 12, 1907, and again on January 11, 1908, exploratory laparotomy was performed for the purpose of removing fluid and more of the papillomatous masses. At the first two operations no oxygen was administered. In each instance there was considerable nausea and vomiting, and decided abdominal tenderness and soreness. At the last two oxygen was introduced into the abdominal cavity. The patient was absolutely free from pain in each case, there was no nausea, no vomiting; her skin was pink when she left the operating table; she came out of the anæsthetic very promptly, and a few hours ofter the operation nourishment was taken with relish and retained.

On March 6, 1908, the patient returned to the Skin and Cancer Hospital, when paracentesis abdominalis under local cocaine anæsthesia was made, and eleven pints of serosanguinous fluid evacuated. Oxygen was administered through the paracentesis needle until normal liver dulness disappeared. Patient felt exhilarated. Returned home forty-eight hours later in good condition.

On November 2, 1908, patient was again admitted to the hospital, and on November 4 laparotomy was performed. More adhesions broken up; a number of retroperitoneal cysts in the mesentery evacuated; a mass of friable, papillomatous tissue, as large as two fists, removed from the upper surface of the liver. On account of the tremendous shock the effects of the intra-abdominal administration of oxygen were not so noticeable at the time, but the patient made an uneventful recovery except for persistent vomiting and reverse peristalsis for some days after operation. This, however, soon disappeared, and the subsequent history presents no notable features. This patient is now at home in very fair condition, able to do light housework.[3]

CASE XXX.—M. O., female, aged 53, housewife. Referred by Dr. J. H. Jenkin, of Shrub Oak, N. Y. Right ovarian cyst; multiple uterine fibromata. Operation at the New York Skin and Cancer Hospital, November 18, 1908. Median incision 8 inches in length. Several pints of ascitic fluid evacuated from

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[3] Reported in previous paper as Case XII. Present report embodies subsequent operations.

the peritoneal cavity. Left ovary and tube normal. Right ovary the seat of a very large cyst, which had become adherent to the stomach and other viscera in the upper abdomen. One large and several small fibroids. Panhysterectomy, only the tip of the cervix being left. The entire mass removed weighed 61½ pounds. Shock very great. Oxygen introduced until the abdomen was ballooned up to very nearly the size it was before the operation. Patient's condition improved. During the entire time the oxygen seemed present in the abdomen (between thirteen and fourteen days) the face was somewhat flushed, the lips more than ordinarily moist and red. The bowels moved without catharsis and with only a small enema, at the end of thirty-eight hours. There was no nausea, no vomiting, and no paralysis of the gut, despite the previous intra-abdominal pressure. Recovery uneventful.

From the series of cases previously reported and from those detailed above, it will be noted that the gas was first employed in the manner described for its effect upon pulse, respiration, etc., as outlined; also that our laboratory experiments were directed toward the verification of the clinical experience along these lines. We are now, however, carrying on a series of animal experiments, to be published later, for the purpose of determining the effect of oxygen upon various organisms, both aërobic and anaërobic, particularly upon the common organisms of sepsis encountered within the body cavities.

Along similar lines, acting upon the suggestions held forth by the work of Thiriar and others, Burkhardt, in Germany, has conducted a series of experiments upon dogs and rabbits, for the purpose of determining the action of oxygen on wounds and infections.[4] He confined his attention to the effect of the gas upon staphylococci and streptococci and their poisonous products. Pure cultures of *Staphylococcus pyogenes aureus* exposed to a continuous stream of pure oxygen showed after a few days very badly developed colonies, which grew quickly after removal from the oxygen atmos-

[4] *Deutsche Zeitschrift für Chirurgie,* vol. xciii, No. 2.

phere. In the incubator the inhibition of growth was less marked, but there was nothing in his experiments that led him to believe that oxygen would entirely inhibit the development of these organisms.

A large part of his investigation was concerned with the question of the extent to which infection of the peritoneum could be influenced by injections of oxygen. It is possible, as he points out, that the filling of the peritoneal cavity with the gas changes the resorptive conditions, or that the oxygen, similarly to normal salt solution, increases the reactive capacity of the peritoneum to infection by bringing about hyperleucocytosis. In the beginning of peritoneal infection there is an energetic absorption, but just as soon as there is a serous or purulent secretion into the peritoneal cavity resorption decreases. As soon as there is a localization of the condition, however, a slowing of absorption is better for the patient because of the danger, in the presence of rapid absorption, that a large amount of bacteria or their toxins may find their way into the blood, thus producing general infection. Oxygen introduced into the peritoneal cavity retards this absorption.

Up to this point our own experiments coincide with those of Burkhardt. He found, however, that oxygen is an irritant to the peritoneum. This has not been our experience. There may be a temporary injection of the capillaries, but certainly no harmful degree of irritation, either in the animals examined, or in the human subject where it has been possible to observe this point.

As I have previously stated, we are now conducting a series of experiments to determine the action of oxygen on certain bacteria and their toxins. In the meantime, we are bearing this feature of the question in mind in our clinical work. While I am certainly not ready to advocate the use of oxygen in every case of septic peritonitis—as I assuredly do feel warranted in using it in tuberculous peritonitis of the cystic or fibrocystic type—nevertheless, in the following cases the gas has been employed so successfully that it gives hope

of some definite utility in septic conditions in the peritoneal cavity.

CASE I.—E. J., male, aged 16 years. Seen in consultation with Dr. A. Austin Becker, Jamestown, N. Y. Acute appendicitis. Operation at the Jamestown Hospital, July 10, 1908. The appendix was found to be gangrenous, with two or three points of ulceration, one ruptured into the peritoneal cavity. The peritoneum was congested for some distance from the caput coli, in the neighborhood of which was a considerable amount of pus and seropurulent material, which was mopped out as far as was possible. The appendix was removed, oxygen introduced, and the wound closed without drainage. Temperature dropped to normal in twenty-four hours, remaining so. Convalescence uneventful, except for an abscess which formed in the deep layers of the wound. This was opened July 16, and allowed to drain for several days. The boy was up and well in two weeks.

NOTE.—The fact that this wound was infected from within is important in relation to the oxygen. There is no question but that this was a septic peritonitis and that the wound was infected from the peritoneum; but where the oxygen was in contact with the infected tissues there was no extension of the trouble. Where, however, the infectious material had come in contact with the walls of the wound not bathed by oxygen, the growth of the bacteria continued.

CASE II.—A. A., female, aged 27, domestic. First seen April 16, in the evening, during an acute attack of appendicitis. Operation, 2 A.M., April 17. The abdomen was found to contain turbid fluid, and the peritoneum to be congested around the caput coli. Some adhesions around the appendix, which was swollen, dark in color, filled with fecal matter, and apparently on the point of rupturing. Adhesions broken up and appendix removed. Oxygen administered intra-abdominally. Temperature dropped to normal within twenty-four hours, remaining so. Recovery uneventful, patient out of the hospital in two weeks. No drainage employed.

Cultures were taken from the peritoneum, and many bacilli coli communis and pus organisms were found.

DR. J. B. GREENE, of Mishawaka, Ind., has furnished me with the data concerning an interesting case in which he em-

ployed oxygen according to the method above described. With the Doctor's kind permission I give below an abstract of the history.

CASE III.—S. B., female, aged 24, married, two children. In an attempt to produce an abortion by means of a wired silk-fibre catheter the patient had punctured the fundus uteri, torn the cervix, and lacerated the vagina on the right side. This occurred at 10 A.M., September 3, 1908. A violent chill followed, the patient went to bed, and another physician was called at 2 P.M. At 8 P.M. patient was taken to the South Bend Hospital, and at 10.30 P.M. she was first seen by Dr. Greene. She was almost *in extremis* at the time, presenting the typical picture of profound sepsis. Believing death to be imminent otherwise, Dr. Greene and his consultants decided to give the patient the only chance afforded by surgical intervention. The abdomen was promptly opened, with as few preliminaries as possible. There was an outpour of blood and fecal matter from the abdominal cavity. The pelvic cavity was filled with clots, fecal matter, and a two months' fœtus. The ascending colon was torn from two inches above the ileocæcal junction, down through the cæcum, an irregular triangle, including the appendix, which had been torn from the cæcum. The uterus was lacerated from the right cornu through, into, and including the vaginal wall, and the right ureter was torn off. The bowel was repaired, the uterus removed, the ureter brought up and fastened in the upper angle of the abdominal wound. After as thorough cleansing as was possible under the circumstances, the abdominal wound was closed, with a small rubber drainage tube in the lower angle. Collodion and cotton were applied around the junction of the skin with the tube, and through the tube oxygen was admitted until the abdomen was fairly well distended. The tube was then compressed to retain the gas, which was allowed to escape after about fifteen minutes. The abdomen was again distended with oxygen, the tube tied securely, dressings applied, and the patient put to bed. Only once after the operation did the temperature go above normal. The patient made an uneventful recovery in sixteen days.

On September 26 the abdomen was again opened and the

ureter grafted to the bladder. Uneventful recovery from this operation also.

A WORD OF CAUTION.

It should be observed that in all severe laparotomies where oxygen is employed in the manner described, it is of the utmost importance to watch for signs of failing strength after the oxygen is absorbed and the patient no longer receives this stimulus. While we do not believe in " postponed shock," there may be a postponed depression after the oxygen is absorbed, and it is then that one should resort to stimulation by other means, in order to tide the patient over. This depression is in no wise due to the fact that oxygen was administered—it has merely been delayed by the oxygen stimulus—and as soon as noted it should be overcome by the administration of the usual stimulants given under such circumstances. In ordinary cases the gas is absorbed in from thirty-six to seventy-two hours.

CONCLUSIONS.

Final deductions concerning the clinical value of oxygen administered intra-abdominally, according to the method above described, cannot be made as yet, but our experience warrants the following tentative conclusions:

1. From Cases I to XVI, reported in my former paper, and from Cases XVII to XXX, detailed above, it may be safely said that oxygen, intra-abdominally administered, has a distinct field of usefulness in lessening shock, hemorrhage, nausea, and vomiting; in overcoming negative intra-abdominal pressure after removal of large tumors; in preventing the formation of adhesions, or, when broken up, lessening the liability of their return; and in influencing favorably certain types of tuberculous peritonitis.

2. From Cases I to II (my own), and Case III (Dr. Greene's), in which the gas was introduced into the peritoneal cavity in septic peritonitis, sufficient beneficial effect was noted to warrant the hope that further clinical experience may establish the efficacy of the gas as an adjuvant in the treatment of this condition.

PLASTIC SURGERY OF BLOOD-VESSELS AND DIRECT TRANSFUSION OF BLOOD.*

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UNTIL very recently the only aim of surgery in the treatment of injuries of blood-vessels was to bring on a perfect hæmostasis. If the injured vessel is the main source of the circulation of blood in an organ, then gangrene follows the vascular trauma, and the organ has to be excised or the limb amputated. Plastic surgery of blood-vessels, *i.e.*, an operative procedure where the final aim is not to arrest the bleeding only but to produce a free circulation of blood through the impaired blood-vessels, is one of the great achievements of modern experimental surgery.

The late development of vascular surgery is due to the special difficulties encountered in dealing with this organ. A blood-vessel is an elastic tube filled with a fluid streaming under high pressure, and coagulating under the influences of the slightest injury. In repairing a loss of continuity of such a tube the surgeon, besides the usual aseptic precautions, has to take into consideration the possibility of a secondary hemorrhage and the formation of thrombosis, with subsequent arrest of the circulation and embolism in some vital organ. Only in 1889 were reported by Jassinowsky [1] the first successful results of suturing of arterial wounds with preservation of the lumen of the vessels. Since then quite a number of investigators have studied the subject. Some have used different mechanical devices to unite the severed ends of the blood-vessels; others produced the anastomosis with the help of sutures of various forms. Of the former may be mentioned Payr,[2] Exner,[3] and Höpfner.[4] The direct suture method was

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developed by Murphy,[5] Carrel and Guthrie,[6] and Carrel alone.[7]
The last investigator developed the finest technic and obtained
the most brilliant results in this domain of experimental
surgery.

Plastic surgery of blood-vessels may consist, according to
S. T. Watts,[8] in *lateral sutures of veins and arteries,* when the
wound of the blood-vessel is either a longitudinal one, or a
transverse one which does not completely sever the two ends.
The *circular suture of arteries and veins* is used in complete
transverse wounds of vessels. *Arteriovenous anastomosis* is
a circular suture between an artery and a vein and finds its
most important application in the direct transfusion of blood.
Transplantation of arteries and veins means an implantation
by the aid of a double circular suture of a segment of an artery
or a vein between the two cut ends of an injured blood-vessel.
This is certainly technically the most difficult vascular opera-
tion.   Carrel classifies these transplantations as *incomplete,*
when the vascular segment is allowed to retain its collaterals
and its normal relations with the surrounding tissues, and
complete, when the segment is completely extirpated before
the anastomosis is performed.   He also distinguishes an *auto-
plastic* transplantation, when the segment is taken from the
same animal; *homoplastic,* when the segment is taken from
another animal of the same species; and *heteroplastic,* when
the segment is taken from an animal of another species.

Now, in connection with these transplantations, there
arises the question as to the nature of the factors which make
success possible.   This question has a technical, operative, and
a general physiological interest.   To implant an arterial seg-
ment successfully means to avoid the formation of an intra-
vascular thrombus after the operation.

According to the generally accepted theory of Brücke,
blood remains fluid as long as it circulates in a vessel lined with
an unimpaired living endothelium.   Should the endothelium
be injured through infection or trauma, a thrombus is formed.
In *incomplete* transplantations the segment certainly remains
alive.   In *complete autoplastic* and *homoplastic* transplanta-

tions, it seems probable that the implanted segments remain alive. But in implantation of arterial segments of different animal species, and segments that had been kept for days in the refrigerator at a temperature between o and 1° C., the question presents itself whether or not these segments really remain alive; and if it is possible to implant devitalized arterial segments, the theories of intravascular coagulation of blood have to be revised.

I have therefore performed, in collaboration with Dr. John H. Larkin,[9] a series of experiments on the transplantation of devitalized arterial segments. The technic followed in our operations was the one elaborated by Carrel. A space on the abdominal aorta of a dog or cat, near the branching off of the renal arteries, is selected. The temporary hæmostasis is done either with a serre-fine protected with a rubber tubing, or with a tape which is twisted and then clamped with an artery forceps. After section of the vessel, the external sheath of the adventitia is pulled over the vessel wall proper and resected. For the suturing I use No. 16 cambric needles and fine silk. Fixing ligatures are placed at equidistant points corresponding on both vessels, and the intervals between the ligatures are sewed together by continuous sutures. The ligatures as well as the sutures perforate the endothelium. The only slight deviation from the Carrel technic which we may mention, is that in small-calibre vessels two fixing ligatures, instead of three, are sufficient. We also came to the conclusion that when the adventitia of the blood-vessel is sufficiently well separated off and both lengths of the silk together are not thicker than the needle, we could do the work just as satisfactorily when we moistened everything with physiological salt solution, instead of with vaseline or paraffin oil. In the first series of our experiments, we transplanted into the abdominal aorta of two dogs and two cats, segments of the abdominal aorta of the same species of animals placed for a few minutes in boiling water. In the second series we transplanted into the abdominal aorta of two dogs segments of a human ureter procured at a fresh autopsy and hardened in 4 per cent. formalin.

In both series the circulation in the femoral arteries ceased very soon after the operation; there developed paralysis of the lower extremities; and the animals died within twenty-four hours after the operation. The autopsies showed that the implanted segment had collapsed and presented a much smaller lumen than the abdominal aorta of the host.

In the third series of experiments we implanted in the abdominal aorta of two dogs and two cats, segments of the abdominal aorta of the same species hardened in 4 per cent. formalin. The segments were selected so as to have the same lumen as the aorta of the host, but as soon as the anastomosis was completed, one could see that both the afferent and the efferent parts of the aorta became wider than the implanted segment, which naturally remained rigid and narrower than the rest of the vessel. The result in every experiment was the formation of a thrombus, paralysis of the posterior extremities, and death within two or three days after the operation (Fig. 1).

We then decided to select segments which would have at the time of the operation a wider lumen than the aorta of the host, though this would increase the technical difficulties. We selected the pectoral aorta of a dog, which was hardened in 4 per cent. formalin, and implanted into the abdominal aorta of another dog. In order to be able to perform the anastomosis, the cut in the abdominal aorta had to be made, not perpendicularly to its long axis, but slanting. The operation was done on two dogs. The first did well for ten days; there was normal pulsation in both femoral arteries. On the eleventh day, the animal was found in the morning with protruding intestines. A secondary laparotomy was performed, but the dog died during the day. Both anastomoses held perfectly; the implanted piece was patent, without any thrombi.

The other animal did well for ten days; there was normal pulsation in the femoral arteries. On the eleventh day we gave the animal anæsthesia in order to dress the wound, and it died in a few hours, apparently from the influence of ether.

The specimen of the aorta presents a very interesting con-

dition.   The distal part of the segment is free from thrombus;
the anastomosis is perfect; in the proximal portion there is a
large thin parietal thrombus covering the suture line, and also
a small gangrenous part of the segment (Fig. 2).

An analysis of these results will show that for ten days the
circulating blood was passing through a dead canal and it
remained fluid.

It seems, then, that blood need not necessarily run through
a vessel lined with living endothelium in order to remain fluid.
The implanted tube need only have a very smooth inner sur-
face, its lumen correspond perfectly to the lumen of the rest
of the blood-vessel, and the line of anastomosis be perfectly
smooth and even.   The implantation of formalin-hardened
segments is technically a great deal more difficult than of seg-
ments freshly obtained or even of those kept in a refrigerator,
as these both retain their elasticity and are able to stretch to
some extent under the pressure of the stream of blood; while,
when a formalinized segment of the same calibre as the rest of
the artery is implanted, it becomes immediately narrower than
the rest of the artery, and thrombosis results.

Carrel found similar difficulties in the implantation of
venous segments.   To quote him: " Thrombosis occurs more
frequently [in venous implantation], due, perhaps, to the
difference of calibre of the vessels generally used."

The formation of a thin parietal thrombus covering a hole
formed by absorption of the segment, indicates that if circu-
lation of the blood is maintained for a sufficient length of
time, there may form a complete new tube over the skeleton of
the implanted segment.   The complete interstitial transforma-
tion with loss of the elastic framework described by Carrel,[10]
may also be explained by the gradual absorption of the im-
planted segment and the formation of a new tube.   Such
knowledge of these great natural repairing powers ought to
give us more courage and stimulate more frequent use of
plastic vascular surgery.

Whether it will really be possible to replace organs of such
complicated functions as the kidneys by the same organs of

FIG. I.

Occluding thrombus beginning above the proximal line of
anastomosis of a formalinized segment.

FIG. 2.

Parietal thrombus, covering the suture line of the proximal portion
of the formalinized segment.

another animal of the same species, is a question which requires a great deal of physiological study. It is possible that such an organ would sooner or later become toxic to the host. It is interesting to note in this connection that while Carrel's animals in which the kidneys were extirpated and replaced by kidneys from another animal of the same species lived at the most only a few weeks, a dog in which both kidneys were extirpated and one of his own kidneys then replaced, lived in perfect health for eight months.

But if during a kidney operation the renal artery should be accidentally torn, an attempt should be made to unite both ends by a transplantation before a nephrectomy is done. The same is true in regard to traumatic injuries of the main arteries of the extremities. Even if a thrombus should form slowly along the line of anastomosis, time may be given to the collateral circulation to form, and a gangrene which would have been the result of a ligature, may be prevented. Ward [11] has shown this recently experimentally in his transplantation of rubber tubing into the aorta of a cat. While in both of his animals an occluding thrombus formed, there was sufficient collateral circulation to give pulsation in the femoral arteries. The same result was obtained by Abbé [12] with the insertion of a glass tube into the aorta of a cat.

The next plastic operation which is of clinical importance is the *arteriovenous anastomosis*. This operation was tried by Jaboulay,[13] Hubbard,[14] F. T. Stewart,[15] and others, in cases of gangrene of the foot, in order to reverse the circulation of the leg from the arteries into the veins, but with hardly any success. I believe the failure is due to some extent to the loss of elasticity of the arteries. An artery with endarteritis obliterans certainly resembles greatly an artery hardened in formalin.

But the main practical application of this operation is in the *direct transfusion of blood*. The therapeutic use of blood transfusion is as old as the history of medicine. But both the transfusion of defibrinated blood and the direct transfusion were extremely dangerous procedures. Consequently, when

Goltz,[16] some thirty years ago, expressed the opinion that death in severe acute bleeding is not due to the fact that the organism lost the cellular elements of the blood, which are needed for the life-metabolism of the tissues, but to the impairment of the mechanics of the circulation due to the loss of fluid, and advised that an infusion of physiological salt solution will save life, the matter found ready acceptance. Since then, and until to-day, it is quite a universally accepted idea that a saline intravenous infusion will do all that a transfusion of blood can do.

Still a number of investigators have shown that intravenous saline infusion is not a life-saving measure in cases of fatal loss of blood. Maydl,[17] Feiss,[18] and Schramm [19] have studied the subject experimentally in the following way. They first determined the amount of blood it is necessary to let out to kill a dog. The necessary quantity is between 4.5 per cent. and 5.5 per cent. of the bodyweight of the animal. They then gave the animals an intravenous saline infusion immediately after such a bleeding, and found that the animals could not be saved by the infusion. Men like Landois [20] and v. Ziemssen [21] came to the conclusion on the strength of these experiments and their own work, that when the loss of blood is such that the remaining quantity cannot sustain the life functions of the organism, then a saline infusion cannot save life; at the most it can afford a temporary relief.

With the new development of blood-vessel surgery, the question of direct transfusion of blood again came to the front, and Crile [22] with his associates has done a great deal of work, both experimental and clinical, to further the subject.

While the operation of direct transfusion has lost most of its dangers, it is still a more serious undertaking than a saline infusion, and it is consequently necessary to investigate whether the former has real advantages over the infusion, and what the advantages are. I have undertaken to approach the question experimentally, and in the following way. A dog was bled from the carotid until the blood ceased to flow out from the cannula inserted in the carotid, and the heart stopped beating.

Then at the last gasping respiratory movements, a direct transfusion from another dog began.   The anastomosis between the carotid of the donor and the external jugular vein of the recipient was prepared at the beginning of the experiment.   The transfusion continued as long as the heart of the donor was beating.   Usually within the first minute from the beginning of the transfusion the heart of the recipient began to beat again, and within the first five minutes from the beginning of the transfusion the dog, which was previously, to all appearances, dead from exsanguination, seemed in just as good condition as at the beginning of the experiment.   The quantity of blood lost by the first dog was between 4.5 per cent. and 5.5 per cent. of its bodyweight.   This experiment was repeated eight times with uniform results.   As a control experiment, I bled a dog also until the heart and respiration stopped, and then made a saline infusion of a quantity of fluid at least double the amount of blood lost, which was 4.5 per cent. to 5.5 per cent. of the bodyweight.   This experiment was repeated six times.   While in every case the heart began to beat again for a time, it was impossible to revive the animals.

As was stated before, a loss of blood of 4.5 per cent. to 5.5 per cent. of the bodyweight is fatal to a dog, and in accordance with the results of Maydl, Feiss, and Schramm, my experiments show that an intravenous saline infusion does not help in such an acute fatal hemorrhage, while the direct transfusion of blood is undoubtedly a life-saving operation. When an organism has lost so much blood that there is not enough left to sustain the vital functions of the organism, a direct transfusion of blood is the only operation of value, though a saline infusion may help, until the surgeon is ready for the transfusion.

On the other hand, it seems to me that in cases of surgical shock where the low arterial pressure is not due to a depletion of the vessels, a saline infusion ought to be sufficient to improve the action of the heart, and increase the blood-pressure, while an addition to the number of the cellular elements of the blood is not needed.   Whether direct transfusion will be of any

benefit in cases of poisoning, intoxications, and diseases of the blood (pernicious anæmia, leukæmia) future work will have to demonstrate. It would seem to me, *a priori*, that whatever etiological moment affected the blood of the host originally would act on the new blood as soon as it was transfused.

A review of the results achieved so far in this field leads to the conclusion that the therapeutic value of plastic vascular surgery is neither as broad nor as general as the most enthusiastic would lead us to believe. Still the progress is great enough already. When one stops to consider besides that it comprises the work of only five years, with barely half a dozen workers engaged in it, one cannot help thinking that if clinical surgeons, with the technical skill which they possess, would devote a small fraction of their time to the study of this and other questions of experimental surgery, the clinic would gain by it a great deal.

FIG. 3.

THE KNY-SCHEERER CO. N.Y.
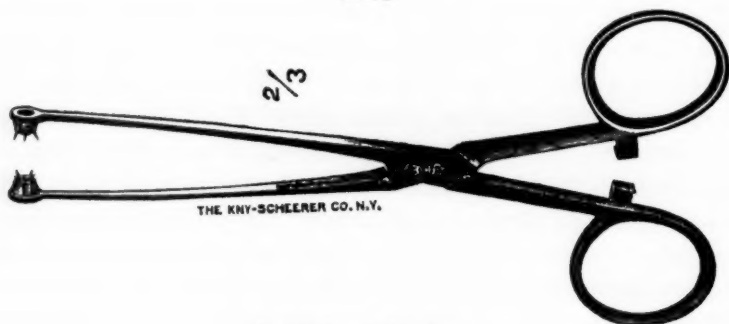
Levin's transfusion clamp.

While in plastic vascular surgery the suture has proved to be of more value than the different cannulas, the temporary anastomosis required for the direct transfusion of blood is more readily and quickly accomplished with the aid of some mechanical appliance. I have designed a clamp which I think requires a less complicated technic and less time for the performance of the operation than Crile's instrument does (Fig. 3).

This instrument presents an artery clamp without the grooves. At the tip of each blade there is attached a small

cannula with a smooth bore.   At the inner edge of each cannula there are attached four small pin-points, and on the outer surface of the cannula there are cut out four grooves.   When the clamp is closed, the pins of one cannula lie in the grooves of the other.   The cannulas have a pyramidal form because the pins are bent outward.   At the beginning of the operation the two halves of the cannula are separated.   The vein is pushed through one cannula and its wall is hooked on the pins.   The same is done with the artery and the other half of the clamp. Then both halves of the clamp are united and clamped.   I believe that when we deal with small blood-vessels it is much easier to hook the walls on the pins than to turn them back like a cuff.   When the clamp is closed, both blood-vessels are connected with the serous surfaces.   Another advantage of this clamp is that when a thrombus obstructs the transfusion the instrument can readily be opened, without disturbing the walls of the vessels, the clots removed, and the clamp closed again.

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NERVE INVOLVEMENT IN THE ISCHÆMIC PARALYSIS AND CONTRACTURE OF VOLKMANN.*

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VOLKMANN's ischæmic paralysis or contracture, as it is variously termed, is a condition which has more often attracted the attention of the orthopædic surgeon than that of the general surgeon or the neurologist, as it is most frequent in children. The condition is apparently fairly frequent but rather to my surprise the reported cases are not at all numerous, probably because the condition is often thought to be due to too tight bandaging or neglect. As we shall see by the published cases this is by no means always the case, though interference with the circulation is probably necessary for the production of the condition. In view of the comparatively small number of reported cases, and the widely varying views in regard to the pathology and the proper treatment of the affection, it has seemed worth while to me to collect and review the published cases, and to add four cases which I have seen during the past few years, as these illustrate a number of the points which have seemed to me the most interesting and important.

CASE I. Dorothy S., 7 years, a patient of Dr. Hunting, of Quincy, was seen by me in consultation on Dec. 26, 1900. In July of that year she had a fall and fractured the right radius. Splints were applied, and were used for four weeks. These splints caused pressure sloughs on both the flexor and extensor surfaces of the forearm. It was then found that the head of the radius was out of place, and in September an operation was done to correct this, and splints were applied again for a time after the operation. This account of the accident and the treat-

ment is not as full as one could wish, but the accident had taken place in a distant part of the country, and more accurate information could not be obtained. It could not be learned how soon after the injury the contractures of the muscles had been noticed.

The examination at that time showed that the head of the radius was still displaced to the outer side so that it was outside of the external condyle of the humerus. There was also bowing of the ulna. On both the flexor and extensor surfaces of the forearm were red, indurated scars. One of these which was somewhat adherent to the deeper tissues was on the flexor side just below the fold of the elbow. Others were just outside the head of the radius, and along the subcutaneous surface of the ulna. There was a contracture of the flexors of the hand and also of the fingers and of the thumb, but the fingers could be almost completely extended when the wrist was flexed. There was well marked atrophy of both the thenar and hypothenar eminences. The muscles of the forearm, both flexor and extensor, responded well to direct stimulation by the faradic and also by the galvanic current. The interossei, abductor minimi digiti, abductor, adductor, opponens, and flexor brevis of the thumb did not respond to faradism, and to the galvanic current showed a typical reaction of degeneration, with slow contraction and anodal closure contraction greater than the cathodal closure reaction. The sensation for light touch was lost, and that for pain and temperature was much diminished, over the whole hand to the level of the wrist, the diminution being greater however in the portion of the hand supplied by the ulnar nerve. In the forearm there was no disturbance of sensation.

The child was referred to Dr. E. H. Bradford and taken into the Children's Hospital for operation. There it was noted on Jan. 2, 1901, that the head of the radius was dislocated outward and there was a bend of the ulna at about the centre. The elbow-joint allowed nearly perfect flexion. Supination was impossible and pronation almost completely limited. On Jan. 3, 1901, Dr. Bradford operated. An incision about three inches in length was made over the middle of the forearm on the anterior surface, dissection was made down to the superficial muscles. Here all the muscles and tendons were found to be imbedded together in a mass of scar tissue in such a way that they could

not be individually identified. Myotomy was done and tenotomy of constricting tendons and muscles so that the fingers could be partially extended. The wound was closed at the lower part with subcutaneous catgut sutures, and above with continuous catgut suture. The wound healed with slight discharge from its lower part, and the child was discharged on Jan. 12.

She was again admitted to the Hospital on Feb. 11, 1901. At this time the condition was much the same as at the previous examination, except that the ring and little fingers could be extended about two thirds the normal amount, and there was considerable gain in the extension of the fore and middle fingers. On Feb. 12, she was operated upon again. An incision about 7 cm. in length was made over the inner side of the palmar surface of the forearm, and dissection was made down to the tendons. The tendons, as at the previous exploration, were bound together in an unrecognizable mass of scar tissue. The tendons were freed by blunt dissection so that the little and ring fingers could be almost completely extended, and the first two fingers and thumb extended to about four-fifths the normal range. The wound was closed with catgut. She was discharged Feb. 21.

The child was seen again by me on April 4, 1901. At that time the small muscles of the hand had practically recovered, the muscles responding normally to the faradic current, and the movements of adduction and abduction of the fingers and thumb being possible. She could not quite extend the fingers fully and the grasp was quite weak, though flexion could be performed. The muscles of the forearm all reacted to faradism though the response in the flexor sublimis digitorum was not a good one. After treatment of electricity, passive movements and exercises was advised. The child returned to her home, and has not been seen since, though Dr. Hunting tells me that the improvement has continued, and she has fairly good use of the hand at the present time.

This case showed the usual course of an injury to the forearm with the use of splints, followed by a slough and subsequent contraction of the flexor muscles of the forearm. The points to which I wish to call attention are the involvement of the ulnar and median nerves by the scar-tissue, and the

recovery from this condition when the pressure upon the nerves has been relieved by the operation upon the dense fibrous tissue which had replaced the flexor muscles of the forearm to a large extent.

CASE II.   Concetta B., six years of age, in Aug., 1904, fell and broke the left arm.   The fracture was treated by a physician, but we were unable to learn the exact details.   On Oct. 3, 1904, she was admitted to the Children's Hospital.   At that time it was noted that there was marked deformity at the left elbow, with a spicule of bone projecting outward.   There was no crepitus but the joint was rigid and flexed at an angle of 45 degrees.   The fingers were contracted into the palm, with the first phalanges extended and the second and third ones flexed, and could not be opened, and there was wasting of the small muscles of the hand.   Sensation could not be tested satisfactorily. The wrist was moderately flexed.   On Oct. 21 an incision was made along the intermuscular septum and across the internal condyle to the upper part of the forearm two and one-half inches in length.   The ulnar nerve was found on the surface of the triceps muscle just under the fascia.   It was blanched and flattened, and appeared compressed by surrounding fibrous tissue.   The internal condyle appeared nearer to the olecranon than normal. The nerve was freed from its fibrous bed, dissected clear of the internal condylar groove and followed downward through the flexor carpi ulnaris muscle.   After it was released the nerve rounded out, and the color changed to pink.   It was then transposed to a point anterior to the internal condyle, the fascia being sutured under it, leaving the nerve between the fascia and the subcutaneous fat.   The fascia was sutured with interrupted catgut sutures and the skin with subcutaneous horsehair sutures.

On Oct. 27 it was noted that the color of the hand was better.   The abductor minimi digiti did not react to faradism, and to galvanism there was a reaction of degeneration, the response being slow and the anode producing contractions with less current than the cathode.   Flexion of the elbow had increased so that it could be brought to a right angle, and extension was about three-quarters of the normal.   Supination was normal.   Extension of the wrist was possible to nearly the full extent, and the contraction of the fingers was less.   On Nov. 3

the response to the faradic current in the small muscles of the hand was still absent, and there was a degeneration reaction. The sensation of the skin supplied by the ulnar nerve tested for pain seemed good. On Nov. 9 there was still some limitation of extension of the wrist, and slight extension of the first phalanges with flexion of the second and third, and a reaction of degeneration. On Nov. 24 the small muscles of the hand reacted slightly to faradism. On Dec. 21 there was good voluntary extension of the wrist and fingers including the terminal phalanges, as well as abduction and adduction of the fingers. The contracture of the flexors was less but some remained and the hand could not be fully extended with the fingers straight. On April 1 the movement of the fingers was normal, but there was still some shortening of the flexor muscles. There was good functional use of the hand in every way in spite of the slight shortening of the flexors.

This case can be differentiated from one of pure injury of the ulnar nerve by the amount of contracture in the flexor muscles, as well as by the condition found at the operation, and shows plainly how the usefulness of the hand may be impaired by the paralysis of the small muscles of the hand as a complicating condition, while the ischæmic contracture is comparatively trifling.

CASE III. Alice M., four years of age, was first seen on Jan. 16, 1907. Early in July, 1906, she fell in running and broke both bones of the left forearm. It was treated by splints, and a week later it was reset after an X-ray photograph had been taken. The splints were worn for six weeks after this. The father thinks the hand was swollen and painful. When the splints were removed there was a slough on the flexor surface of the forearm and another on the back, and it was noticed that the fingers were contracted so that the hand could not be opened.

On examination there was a movable superficial reddish scar at the junction of the middle and upper thirds of the flexor surface of the left forearm, while the deeper muscular tissue was firm and hard though the skin was not adherent. This scar was irregularly circular, and about three-quarters of

an inch in diameter. There was another scar somewhat irregular in shape about two and one-half by half an inch in measurement on the dorsum of the arm, nearer the elbow and running down along the radius, which like the first one was movable. There was no voluntary flexion of the proximal phalanges, extension of the terminal ones, or adduction or abduction of the fingers possible. The grasp was practically nil. Supination was weak, but could be performed nearly to the full extent. The thumb lay in the palm of the hand, and could not be opposed. There was moderate atrophy of the small muscles of the hand. There was slight extension of the first phalanges of the fingers and flexion of the second and third, with marked contracture of the flexors of the hand and fingers which could be partly overcome. The muscles of the hand supplied by the ulnar nerve did not react to strong faradism, while all the other muscles did, including the flexor muscles in the forearm. The prick of a pin was felt on the ulnar side of the hand, but there was perhaps diminished sensation in this area. The fingers could be extended fully only when the hand was at right angles with the arm.

Passive movements and electricity were advised and the treatment was followed out very faithfully, and power gradually returned in the small muscles of the hand, so that in six months adduction and abduction of the fingers, and opposition of the thumb was fair, and these muscles all responded to faradism, and the atrophy had disappeared. The child could pick up a piece of paper and hold it with the fingers of this hand. There was some further improvement so that at the end of a year after she was first seen there was no evidence of the former trouble with the muscles supplied by the ulnar nerve. The grasp, though not strong or complete, had improved, and the child could carry a considerable weight in the hand, and by using moderate force the hand and fingers could be brought into the line of the forearm though not beyond, and when the tension was relaxed the hand was flexed at an angle of about 30 degrees from the direct line, but there was good functional use of the hand in spite of the moderate contracture remaining.

CASE IV. A boy, William I., 12 years of age, was first seen in consultation on Sept. 26, 1907. On July 1 of that year while running he fell and struck the elbow and was said to

have fractured the ulna just below the elbow-joint. He was treated by the application of a right angled internal splint for three weeks as the mother said, but the boy himself said for five weeks. The night of the accident he suffered severe pain all night, but after that he did not have much pain, but the arm felt dead and the next day he could not move the fingers and the hand was swollen. When the splint was removed he was given passive movements. Only later was it noticed that the wrist and fingers were contracted. An X-ray picture that was taken showed the fragments in good position.

Examination showed that with passive motion the right arm at the elbow could be fully extended, but flexion was to an angle of 80 degrees only, supination nearly full, and pronation to about 10 degrees beyond the mid-position. Strength in flexion, extension, and supination was good while pronation was weak. Flexion of the wrist was done with fair strength, as was extension of the wrist. The grasp was fair. Abduction and adduction of the fingers could be done, but was very weak, and the same was true of flexion of the proximal phalanges and extension of the second and third ones. Extension of the proximal phalanges was good. There was marked atrophy of the hypothenar eminence, and to a less extent of the thenar. There was a contracture of the flexors of the fingers. The fore-arm muscles reacted well to faradism. The small muscles of the hand (abductor minimi digiti) reacted very slightly to strong faradism, and showed no response to direct stimulation by the galvanic current with moderately strong currents. The hand was slightly cyanotic. Sensation for light touch was lost in the whole hand, and much diminished for the prick of a pin, but this diminution was greater over the region supplied by the ulnar nerve than in the other parts of the hand. The internal condyle was in good position. A firm mass, similar to scar tissue, could be felt in the flexor muscles of the forearm at about the middle, and a little to the ulnar side. Massage and the faradic current was advised.

He was next seen on Jan. 8. During this interval some operation had been done at some hospital, apparently upon the head of the radius, as there was a scar about an inch and a quarter long on the flexor surface of the arm just below the fold of the elbow. The contracture of the flexor muscles of

the arm remained about the same, as also the strength of the grasp. The atrophy of the small muscles of the hand had practically disappeared, and the movements of the fingers such as adduction and abduction were much stronger, while all the small muscles of the hand reacted well to the faradic current, as did the flexor and extensor muscles in the forearm, and there was good functional use of the hand. The massage and passive movements were continued.

The study of the cases of ischæmic paralysis and contracture reported in the literature shows very clearly that this condition varies greatly in severity in different instances, and that in many of the cases we are dealing with complications of the primary trouble from secondary involvement of some of the nerve trunks of the arm which produce disturbances which cannot be relieved by the treatment of the contractures only. So that the individual case must be carefully examined with the question of nerve involvement in mind and this condition considered in determining the treatment. This condition often and perhaps usually explains the great variation in results obtained in different cases by the same method of treatment, so that in one case a nearly perfect result is reported and in another practically no improvement is obtained, though of course the result varies also with the completeness of the destruction of the muscle tissue. The adaptation of the treatment chosen to the varying conditions present is then the problem with which the surgeon is confronted.

The first report of this condition of the muscles is usually accredited to Volkmann in 1875, but the same case is found in an earlier edition of the same book published in 1869, and in addition Hildebrand quotes a case of Hamilton's in 1850 without giving the reference, and I have been unable to find the original article or book. The credit of calling general attention to the condition, however, belongs to Leser, and the affection is sometimes called the Volkmann–Leser contracture. The pathology has been fairly well understood from the time Volkmann called attention to the condition, and especially since the appearance of Leser's article in 1884. There has been considerable dispute however over the mechanism of the process,

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TABLE OF REPORTED CASES

No.	Author	Sex, age	Character of injury	Treatment of injury	Pulse	Pain	Swelling
1	Volkmann 1869	M 16	Hydrops of knee	Posterior splint	....	3 days	....
2	Leser 1884	M child	Fracture humerus	Plaster and reapplied	....	3 hours	3 hours
3	Leser 1884	M child	Fracture right hume-rus above condyles	Plaster	....	Few hrs.	Some
4	Leser 1884	M ?	Fracture elbow-joint	Plaster	....	Yes	Yes
5	Leser 1884	F child	Contusion	Plaster	....	Yes	Yes
6	Leser 1884	M ?	Fracture of forearm, direct violence	Splint, then plaster	....	....	....
7	Leser 1884	M ?	Fracture mid-forearm	Plaster	....	....	Yes
8	Leser. 1884	M ?	Fracture radius	Plaster	....	Yes	Yes
9	Sonnenkalb 1885	M 25	Fracture middle left humerus	Splints	....	No	Yes
10	Petersen 1888	M 4½	Fracture humerus close to elbow	Pasteboard splint and light bandage	Dim.	....	....
11	Nolte 1889	F child	Supracondylar frac-ture right humerus	Splint	....	2 hours	Yes
12	Hildebrand 1890	M 5	Fracture middle right radius	Splints	....	Yes (next day)	Yes
13	Niessen 1890	F 34	Fracture styloid left radius	Plaster, splints for 6 weeks	....	Yes	Yes, soon
14	Niessen 1890	M 10	Fracture lower epiphy-sis of humerus	Splint for 3 days	....	Yes	Yes
15	Davidsohn 1891	M 2	Fracture lower third forearm	Splint	....	Soon	Yes
16	Pingel 1892	M 10	Fracture humerus into joint	Plaster	....	Yes 3 days	Yes
17	Pingel 1892	M 6	Fracture left humerus near elbow	Plaster	....	....	Yes
18	Keferstein 1893	M 10	Fracture left forearm	Splints	....	....	Yes
19	Keferstein 1893	M 9	Fracture middle right radius	Splints	....	Yes	Yes

GATHERED FROM LITERATURE

| Elect. reactions | | Sensation | Atrophy | Pressure scar | Trophic | Contraction | Paralysis | Treatment and result |
F.	G.							
Dim. in gastroc.		....	No	....	....	Gastroc.	....	No operation. Slow recovery.
Arm muscles 0	sl.	Normal	....			Yes	....	No operation. Slight improvement.
Arm muscles 0	sl.	....	....			Yes	....	Displacement of fragments. No operation. Improved.
Arm muscles 0	sl.	Normal	....	Yes	....	Yes	No motion of fingers	No operation. Slight improvement.
Arm muscles 0	sl.	....				Yes	....	No operation. Slight improvement.
Hand muscles 0	sl.	....				Yes	No motion fingers	Dislocation of upper fragment. No union. Operation on pseudo-joint. Improved.
Hand muscles 0 Arm muscles 0	sl. sl.	....				Yes	Slight motion fingers	No operation. Improvement.
Hand muscles 0 Arm muscles 0	sl. sl.	Normal				Yes	....	No operation. Almost complete recovery.
Arm muscles 0	sl.	Lost in hand	....	....	Yes	Yes	Extension 1st, flexion 2d and 3d phalanges	No operation. Improved.
		Dim. in fingers	....	....		Yes	....	Operation. Median nerve compressed. Artery injured and obliterated below. Improved.
		....	....	No	Blue and cold	Slight	....	Bandage used for extension left on and compressed arm. Splint off in 24 hours. Medical treatment. Well in 16 weeks.
		....	....	Yes	....	Marked	....	Massage and stretching. Improved.
Arm muscles very sl. ——— Hand muscles sl. ———		Lost in ulnar region	Yes	....	Cyanosis skin, shiny ulcers	Yes in 5 days	Yes in forearm and interossei	Massage and electricity. Improved. Could work.
Flexors 0 ——— Hand 0 ———		Lost in hand, more in ulnar region	In arm	....	Cold	Yes	....	Massage and electricity. Improved.
Arm muscles dim. dim. Hand muscles dim. dim. Thumb muscles almost 0 R. D.		Normal	In arm	Yes	Blisters on fingers	Yes	No motion of fingers	Tendons lengthened. Moderate good movement. Reaction of degeneration remained in thumb muscles.
Arm muscles 0 0 Hand muscles 0 0		Lost in fingers	Arm muscles hard	....	Blisters	Yes	No motion fingers except metacarpal joint	Massage and movements. No improvement.
Arm muscles 0 ——— Hand muscles 0 ———		Lost in fingers, dim. in arm	In arm, muscles hard	....	Blisters on arm, hand cold	Yes	Paralysis fingers, thumb in plane of hand	
Arm muscles sl. ——— Hand muscles 0 ———		Numb, lost in hand	In both arm and hand	....	Blisters, cyanotic	Yes	....	Movements (stretching). No improvement. Same condition 16 yrs. later.
....		Dim.	In arm	Yes	Blisters, cyanotic	Yes	....	Passive motion. 12 years later no motion in fingers, which were flexed in 2d and 3d phalanges. Sensation normal.

TABLE OF REPORTED CASES

No.	Author	Sex, age	Character of injury	Treatment of injury	Pulse	Pain	Swelling
20	Keferstein 1893	M 6½	Supracondylar fracture humerus	Pasteboard splint, bandage to upper arm only, 5 days	....	Yes (first	Yes night)
21	Keferstein 1893	M 8	Fracture left humerus near elbow	Plaster 2 days, splint 2 weeks	....	....	Yes
22	Keferstein 1893	M 9	Fracture of elbow	Splint	Did not bleed when stuck	Yes	Yes
23	Keferstein 1893	M 6	Fracture left elbow-joint	Plaster	....	....	Yes
24	Keferstein 1893	M 25	Crush right forearm, open wound	Splints	....	......	....
25	Langer 1895	F 50	Embolus left arm	Quick stretching	Gone, later returned	Yes	Yes
26	Garré 1895	M 10	....	....	....		....
27	Battle.................. 1896	M 12	Fracture forearm	Splints	....		....
28	Henle.................. 1896	 9	Fracture right forearm	Plaster	....	Yes	Yes
29	Dunn 1897	M 12	Fracture forearm	Splints	....	Yes	....
30	Kaempf.......... 1897	M 4	Fracture humerus just above elbow	Plaster	....		Yes
31	Johnson.................. 1898	M 8	Fracture lower end humerus	Splints	....		....
32	Owen.................. 1898	......	Fracture upper forearm	....	....		....
33	Davies-Colley.......... 1898	F 3	Fracture about elbow	....	....		....

GATHERED FROM LITERATURE—*Continued*

	Elect. reactions		Sensation	Atrophy	Pressure scar	Trophic	Contraction	Paralysis	Treatment and result
Swelling	F.	G.							
Yes (ight)	....		Normal	Yes	....	Blue	Yes	Extension 1st, flexion 2d and 3d phalanges	Stretching. Improved. In 1902 had returned. No grasp and hand cold.
Yes	....		Lost in ulnar region and tips fingers	....	....	Ulcers on fingers	Yes, fingers and wrist	Small hand muscles. 1st phalanges extended, others flexed	Projection of fragment prevents flexion elbow. Operation for this, then electricity and massage. Improved. Lost claw-hand. 19 months later some grasp. Hand cold.
Yes	....		Lost in hand except radial area and thumb	Arm and hand muscles hard and lump in middle arm	....	Ulcers on fingers	Yes	1st phalanges extended, others flexed	Operation on fragments of radius. Movements and electricity. No motion of thumb. Slight grasp only. 1 year later contraction had returned.
Yes			Much dim. in whole hand, less in thumb and first finger	....	....		Yes, flexors hard	....	Stretching. Some improvement.
	....		....	....	Yes, adherent	....	....	....	Stretching under ether. Movements. Improved, but not a good fist.
Yes	Arm muscles 0 0 Hand muscles 0 R. D.		Paræsthesia. Lost in hand	....	....	....	Of flexors, muscles hard	1st phalanges extended	Movements. Slight improvement.
	....		....	....	....	....	Severe. Fingers into palm	....	Shortened bones and operated on contracture at elbow
....	Normal except hand muscles, where R. D.		Normal	Of hand muscles	Yes	....	In flexors	....	Exercises and galvanism.
....	Normal		....	....	....	....	Yes	....	Resection bones. Slow union. Great improvement.
Yes	....		Normal everywhere	Thenar muscles	Yes	Fingers cold and red	Yes	....	Operation advised. Too soon to know result.
Yes	Arm muscles 0 R. D. Hand muscles 0 R. D.		Dim.	In hand and arm Muscles hard	....	Cyanosis	Yes	Hand muscles	Movements. No change.
....	....		....	....	Yes	....	Yes	Muscles fibrous	Operation. Nerves found normal at seat of injury. Resection of bones. Fibrous union only, but position of hand satisfactory.
....	....		....	....	....	....	Yes	Muscles fibrous	Operation of lengthening tendons. Satisfactory results. Median nerve found healthy.
....	....		Normal	Flexors in arm	....	....	Yes	1st phalanges extended, 2d and 3d flexed. No abd. or add. fingers	Projection of humerus removed. Lengthening tendons. Could not flex fingers. Could move thumb.

No.	Author	Sex, age	Character of injury	Treatment of injury	Pulse	Pain	Swelling
34	Davies-Colley............ 1898	......	....	....	......	......	......
35	Clarke................. 1899 (quoted Powers)	M 6	Fracture lower end humerus	Splints	......	......	......
36	Thomson 1900	F 4	Dislocation backward, both bones forearm	Splints with passive movements	......		
37	Edington 1900	F child	Dislocation backward, both bones forearm	Splints	......	......	......
38	Page.................... 1900	M 4½	Fracture lower end humerus	Splint	......		
39	Littlewood.............. 1900	F 8	Fracture lower end humerus	Splints 5 weeks	......	......	Yes
40	Littlewood 1900	F 6	Fracture about elbow, and both bones forearm	....		......	Great
41	Owen................... 1900	M 30	Fracture both bones forearm few inches from wrist	Splints, tight	......	Yes	Yes
42	Schloffer............... 1901	M 18	Gunshot wound of thorax. Embolus	None	None	Yes	Yes
43	Wallis 1901	F 2)	Operation, fracture ulna, lower third	Splint	......	......	Yes
44	Barnard 1901	F 3	Fracture both bones forearm	Splints	......	No	......
45	Barnard 1901	M 4	Crush of forearm, no fracture; hemorrhage and swelling	Splints, light bandage			......
46	Henle................... 1902	M 8	....	....	......		......
47	Galloway 1902	...... child	Comp. fracture forearm	....			......
48	Riedinger............... 1902	M 33	Crush forearm, no injured bones	Splints	......	......	Yes
49	Riedinger............. 1902	F 15	Crush of finger	Elastic bandage 2 days, gangrene	......	......	......

GATHERED FROM LITERATURE—*Continued*

Elect. reactions F.	Elect. reactions G.	Sensation	Atrophy	Pressure scar	Trophic	Contraction	Paralysis	Treatment and result
			Wasted and fibrous arm			Yes	Median and ulnar compressed by scar tissue	
						Yes		Tenotomy. No mention of function.
			Flexors in arm		Hand livid and cold	Yes		
Arm muscles dim.	dim.	Normal			Livid and cold	Early		Tendons lengthened. Good motion, but not complete flexion.
Arm muscles	R. D. at first	Ulnar anæsthesia	Slight wasting, first interossei	Yes		Marked		Tendons lengthened. Good result. Makes fist.
		Dim. ulnar reg.		No		Yes		Projection above elbow-muscles hard. Tendons lengthened. Useful hand.
				Yes		Yes		Tendons lengthened. Some flexor power.
Hand muscles o	R. D.	Little feeling in hand	Hypothenar group	Yes		Yes		Resection bones. Tendons lengthened. No union. Resection repeated. No solid union.
Affect. muscles	R. D.	Dim. hand and arm, normal in upper arm			Cyanosis arm and hand	Yes		Muscles hard.
		Lost in median, radial, ulnar	Hand muscles		Red, cyanotic	Yes	Main en griffe	Massage. Then tendons lengthened and median nerve freed from fibrous tissue. Sensation improved in median area, not in ulnar. Motion improved.
	R. D.		Thumb muscles	Yes	Whitlow	Yes	Main en griffe	Tendons lengthened. Muscles fibrous and dry. Fair grasp. Not fist. Half normal.
	R. D.	Not definite			Skin glossy, hand cold, Whitlow	In 5 weeks	Main en griffe	Tendons lengthened. Fair grasp. Half normal.
						Yes		Resection bones. Good results. Hand useful.
				Yes		Yes		Tendons lengthened. Grasp good. Perfect function.
			In arm			Yes	Flaccid 4th and 5th fingers, contracted thumb, 2d and 3d	Not stated.
Arm muscles, qualitative changes Hand muscles, quantitative changes			In arm, not in hand				Anchylosis finger and hand joints	Not stated.

No.	Author	Sex, age	Character of injury	Treatment of injury	Pulse	Pain	Swelling
50	Riedinger.............. 1902	M 10	Fracture left elbow, 1896	....	....	....	....
51	Dudgeon 1902	F 5	Fracture humerus just above elbow	Splints	....	....	Yes
52	Dudgeon 1902	M 20	Forearm struck by hammer	Splint, then plaster 2 weeks	....	Slight	Yes
53	Dudgeon................ 1902	M 5	Fracture forearm, both bones, upper and middle third	Splints	....	Tender	Slight
54	Dudgeon 1902	F 4	Fracture humerus just above elbow	Plaster	....	No	Yes
55	Ward.................. 1902	F 21	Crush, no fracture	Sling	....	Yes	Yes
56	Ward.................. 1902	M 12	Fracture forearm three years before	Splint	....	....	....
57	Dudgeon................ 1903	 5	Fracture humerus near elbow	Plaster	....	....	Yes
58	Dudgeon 1903	M 9	Fracture forearm	Splints	....	No	....
59	Dudgeon 1903	M 8	Fracture forearm	Splints	....	No	....
60	Edington 1903	F 7	Fracture forearm	Splints	....	Yes	Yes
61	Edington 1903	F 32	Septic infection forearm at 15 years	Multiple incisions, splints	....	....	....
62	Hohn.................. 1903	......	....	Splint	....	....	....
63	Martin, C. and F. 1903	F 4½	Fracture both bones forearm	Splints	....	....	Yes
64	Martin, C. and F. 1903	M 5½	Fracture lower radius	Apparatus	....	....	....
65	Lycklema and Nyeholt.. 1904	M 7	Fracture arm	Plaster	....	....	....
66	Schramm 1904	F 6	Fracture both bones forearm	Splint	....	Yes	Yes
67	Drehmann.............. 1904	M 7	Fracture elbow-joint	Plaster	....	Yes	Yes
68	Thomson 1905	M 14	Fracture arm	Splints	....	....	....
69	Rowlands.............. 1905	F 6	Fracture both bones forearm, middle bruised	Splints	....	No	Yes
70	Willmann.............. 1905	M 6	Fracture elbow	Splints	....	Yes	Yes

GATHERED FROM LITERATURE—*Continued*

CASES Swelling	Elect. reactions F.	G.	Sensation	Atrophy	Pressure scar	Trophic	Contraction	Paralysis	Treatment and result
....	....	....	....	....	....	Yes	No motion hand or fingers	Stretching in 1898. Contracture at wrist; has improved motion.
Yes	Normal nerve and muscle	Normal	In arm	Yes	Hand cold	Yes	Interossei act fairly	Massage. No improvement.
Yes	3 years later nerve and muscle normal	Normal	In arm	No	No	Yes	All movements diminished	Massage and electricity. Good extension but tendons short.
Slight	Normal, 3 years later normal	Normal	Slight in arm	....	....	In 5 weeks	....	Massage and galvanism.
Yes	Normal except ulnar dim. dim. 10 months later all normal	Normal	In arm	Yes	Hand cold	Yes	Extension 1st, flexion 2d and 3d phalanges. Interossei fair	Massage and passive motion. Motion remained limited.
Yes	....	Normal	....	....	....	Yes	....	Depression in belly of muscle. Tendons lengthened. Fair grasp and motion.
....	Lost	Dim. in median and ulnar	....	Yes	Skin shiny, livid; ulcers	Yes	Extension 1st, flexion 2d and 3d phalanges	Tendons lengthened. Infection. Result not known.
Yes	Practically normal	Normal	....	Yes	....	Yes	....	Massage and faradism. Improved.
....	Partial R. D. ulnar 2½ years after, later normal	Dim. ulnar region	....	Yes	Cold and blue	Yes	Partial ulnar supply	Massage and electricity. One year later resection. Union. Great improvement.
....	Normal 9 m. later	....	In arm	Yes	....	Yes	....	Resection bones. Union. Great improvement.
Yes	Arm and hand norm. norm. except dim.	Normal	....	Lower forearm	Blisters; livid skin, glossy	Yes	....	Tendons lengthened.
....	All good except thenar muscles o dim.	....	....	....	....	Yes	....	
....	....	....	....	....	....	Yes	....	Resection bones. Improved. Slight motion.
Yes	....	Dim. in hand	In hand	Yes	....	Yes	Extension 1st, flexion 2d and 3d phalanges. No motion	Elastic extension. Improvement.
....	....	Normal	No	....	....	Yes	....	Osteotomy. Fair result.
....	....	....	....	....	....	....	....	Tendons lengthened. Stretching. Improved.
Yes	....	Normal	In arm	Yes	Skin changed	Yes	....	Tendons lengthened. Could hold needle. Some contracture.
Yes	....	Normal	Thumb muscles	Yes	No	¡Yes	....	Operation. Myotomy, freeing nerve. Great improvement.
....	Modified, later normal	Modified, later normal	....	....	....	Yes	....	Electricity. Massage. Considerable improvement.
Yes	In contracted muscles — no R. D.	Lost median nerve	....	Yes	Hand blue, chilblains	Yes	1st phalanges extended, others flexed	Resection bones. Union. Good grasp. Later tendons lengthened. Much interstitial fibrosis.
Yes	....	Normal	In arm	Yes	....	Yes	Claw-hand	Resection bones. Makes fist. Spreads fingers. Slight contracture. Use perfect.

TABLE OF REPORTED CASES

No.	Author	Sex, age	Character of injury	Treatment of injury	Pulse	Pain	Swelling
71	Kob...................... 1905	M 10	Fracture elbow	Plaster	....	....	Yes
72	Bardenheuer............. 1906	F 6	Fracture lower epiph. humerus	Plaster	....	....	
73	Bardenheuer............. 1906	M adult	Fracture clavicle	Tight bandage	Gone	....	....
74	Bardenheuer............. 1906	M 8	Fracture humerus, supracondylar	....	Absent	....	Yes
75	Bardenheuer............. 1906	F 5	Fracture, supracondylar	Plaster	....	....	
76	Bardenheuer............. 1906	M adult	Rupture popliteal artery	....	Lost		....
77	Bardenheuer............. 1906	M 12	Injured leg at operation	....	....	....	Yes
78	Bardenheuer............. 1906	M 40	Fracture both bones leg, injured artery	....	Lost		....
79	Hamilton .... 1850 (quoted by Hildebrand)	M 9	Fracture humerus, supracondylar	....			....
80	König.................. (Hildebrand)	......	Fracture humerus, supracondylar	....			....
81	König.................. (Hildebrand)	......	Fracture humerus, supracondylar	Plaster	....		....
82	König.................. (Hildebrand)	......	Fracture elbow	Splints	....	....	....
83	König.................. (Hildebrand)	......	Fracture elbow	Plaster	....	....	
84	König.................. (Hildebrand)	......	Fracture humerus just above elbow	Plaster	....	....	
85	König.................. (Hildebrand)	......	Fracture humerus, supracondylar	Plaster	....	....	....
86	König.................. (Hildebrand)	......	Fracture radius, middle	Splints	....	....	
87	König.................. (Hildebrand)	......	Fracture forearm	Splint	....	....	....
88	König.................. (Hildebrand)	......	Fracture radius, middle	Splints, tight	....		....
89	Helferich .... (Hildebrand)	......	Fracture humerus	Plaster	....	....	......

GATHERED FROM LITERATURE—*Continued*

Swelling	Elect. reactions		Sensation	Atrophy	Pressure Scar	Trophic	Contraction	Paralysis	Treatment and result
	F.	G.							
Yes	....		Lost in hand except radial	Slight in arm, thenar muscles	Yes	Cyanosis	Yes	....	Massage and electricity. Later resection bones. Improvement. Thumb could be opposed.
....	Muscles good ——— nerves, radial, median, ulnar 0		Normal	....	Yes		Yes	....	Massage. Improvement.
....	....		Lost whole hand	....	....	....	Flexors in fore-arm	Paralysis all nerves	
Yes	....		First normal, then dim.	....	....	....	Yes	In median supply	Operation. Artery obliterated. Median nerve compressed. Nerve freed. Complete recovery.
....	Changes in median and ulnar		Lost	....	Yes	Skin glossy	Yes	Ulnar paralysis, extension 1st phalanges, others flexed	Operation. Artery occluded. Freed nerves. Dissect off muscles. Fingers recovered. Slight improvement.
....	....		Lost at first, later turned	....	....	....	In calf	Muscles paralyzed	Later necrosis. Amputation. Fibrous changes in muscles.
Yes	....		....	....	....	....	Tendon hard, swelling in calf	Paralysis of nerves	Later dry gangrene.
....	....		....	....	....	....	....	Nerves normal	Superficial gangrene. Ischæmic inflammation in calf.
....	....		Much dim. hand and arm	....	....	....	Yes	Extension 1st phalanges, flexion others	Median nerve felt over projection of bone. Operation on deformity. No improvement.
....	....		Normal	....	....	....	Yes	....	Some improvement.
....	....		Disturbed median, ulnar, radial	....	....	....	Yes	....	Improved.
....	....		Lost in fingers	....	....	....	Yes	....	Freed median nerve. No improvement.
....	....		Disturb'd	....	....	....	Yes	....	Little improvement.
....	....		Disturb'd	....	....	....	Yes	Hand muscles	Improved.
....	....		None	....	....	Cold	Yes		
....	....		....	....	....	....	Yes	....	Recovered.
....	....		Lost in hand	....	....	....	Yes	....	Sensation returned.
....	....		....	....	....	....	Yes		
....	Arm muscles dim. ——— Hand muscles 0		....	....	....	....	Yes		

TABLE OF REPORTED CASES

No	Author	Sex, age	Character of injury	Treatment of injury	Pulse	Pain	Swelling
90	Helferich .... (Hildebrand)	......	Fracture humerus at elbow	Plaster	....	....	....
91	Hildebrand 1906	M 24	Fracture humerus	Splint, pad in axilla	....	Yes	Yes
92	Hildebrand 1906	M 10	Fracture humerus, lower part	Bandage, fragments displaced	....		
93	Hildebrand 1906	M 13	Fracture elbow and lower third radius	....			
94	Hildebrand 1906	M 7	Fracture humerus	Plaster	....		
95	Ferguson 1906	M 9	Fracture both bones forearm at middle	Splints			
96	Ferguson 1906	F 12	Fracture humerus, lower part	Splints, tight	....		
97	Powers 1907	M 17	Stab wound	Esmarch 25 hrs., splints	Present	Moderate	Moderate
98	Huntington 1907	M 5	Fracture both bones forearm	Splints. then plaster	....		
99	Boynton 1907	F 5½	Fracture humerus just above elbow	Splint	....	No	Yes
100	Hoffmann, E. 1907	F 6	Fracture humerus, lower third	....	Absent	....	
101	Wallstein 1907	......	....	....	....	....	
102	Kleinschmidt 1907	M 7	Fracture humerus, supracondylar	Plaster	Absent, brachial, weak, radial	....	
103	Quinby 1908	M 15	Fracture elbow, both condyles, X-ray	Splint	....	Yes	Yes
104	Thomas................. 1908	F 7	Fracture radius, displacement head	Splints	....	....	
105	Thomas................. 1908	F 6	Fracture elbow, displacement	....	....	....	....
106	Thomas................. 1908	F 4	Fracture both bones forearm	Splints	....	Yes	Yes
107	Thomas................. 1908	M 12	Fracture ulna, near elbow	Splints	....	Yes	Yes

GATHERED FROM LITERATURE—*Concluded*

Elect. reactions F.	G.	Sensation	Atrophy	Pressure scar	Trophic	Contraction	Paralysis	Treatment and result
		Present in fingers				Yes	Of fingers	
Arm muscles 0 Hand muscles 0	0 0	Lost in ulnar reg.	Arm and hand muscles			Yes	Of hand muscles	Operation. Dissected out compressed nerves. Little effect.
Muscles normal 0 Ulnar n. —— R. D.	0			Yes		Yes		Operation. Muscles fibrous, nerves compressed. Recovery function of nerves.
Arm muscles 0 Hand muscles norm. ——	——	Dim. in thumb and first finger			Hand blue and cold	Yes	Median supply	Freed and dislocated nerve. Sensation improved. Could make a fist.
			In hand			Yes	No motion in hand	Freed, resected, and dislocated median and ulnar nerves.
Arm muscles responded		Normal	In arm			Yes		Lengthened tendons. Freed median and ulnar nerves and stretched them. Improvement.
		Lost in hand	In arm	Yes	Hand cold	Yes	Extension 1st phalanges, flexion 2d and 3d	Tendons lengthened. Nerves found compressed. Sensation improved. Fair use.
Arm and hand 0	0	Lost in arm and hand	In arm		Blebs arm and hand, skin shiny	Yes	No motion fingers	Freed median and ulnar nerves. Sensation improved. No active motion.
				Yes		Yes		Resection bones. Union. Improvement. Half normal motion.
				Yes		Yes		Massage. Improvement.
Muscles of median 0 or dim. ——						Yes		Collateral circulation about condyle. Tendons lengthened. Good results.
						Yes	Claw-hand	Tendons lengthened.
Uncertain		Dim. ulnar region	In arm and hand			Yes		Massage. Later resection. Normal union. 3d operation. Slow union.
		Lost in ulnar			Ulcer on fingers	Yes	Extension 1st phalanges, flexion others	Ulnar nerve stretched and dislocated. Practical recovery.
Arm muscles sl. dim. Hand muscles 0	sl. dim. R. D.	Arm normal, hand much dim.	Hand muscles	Yes		Yes	Hand muscles	Myotomy. Tenotomy. Jan., 1901. Hand muscles recovered. Grasp fair.
Hand muscles 0	R. D.		Hand muscles	No	Hand blue	Yes	Hand muscles	Oct. 21, 1904. Dislocation ulnar nerve. Hand muscles and sensation recovered. Slight contraction. Practical recovery.
Arm muscles dim. —— Hand muscles 0		Dim. ulnar region	Hand muscles	Yes		Yes	Hand muscles	Electricity and passive movements. Hand muscles recovered. Grasp fair. Moderate contracture remained.
Arm muscles norm. Hand muscles dim. 0		Dim. in hand, especially ulnar	Hand muscles	No	Hand cyanotic	Yes	Moderate paralysis hand muscles	Electricity and passive movements. Hand recovered. Moderate contracture remained.

some authors calling cases of pure flaccid paralysis of muscles
after thrombosis of arteries an ischæmic paralysis.

MANNKOPF published such a case under the title of peripheral ischæ-
mic paralysis in 1878 where he examined the nerves and vessels. This
was a case of embolism where there was a complete flaccid paralysis
of both legs. He found in the nerves, degeneration of the nerve fibres
and also alterations in the nerve sheath, which is evidence of both a
parenchymatous and interstitial neuritis, while the muscles showed loss
of striations, fine granular cloudiness and increase of the sarcolemma
nuclei. Both nerves and muscles thus showing changes due to the
cutting off of circulation.

MOLITOR in 1889 published a similar instructive case of dislocation
of the elbow with injury of the brachial artery where the hand became
cold and without sensation and marked swelling and œdema developed
with absence of the pulse in the radial, ulnar, and lower part of the
brachial arteries, and an effusion of blood at the bend of the elbow.
At operation it was found that the median nerve was uninjured and
the hæmatoma was removed and the sensation in the hand improved.
Eight days later the arm was amputated and on examination it was
found that the forearm muscles were little changed, being œdematous,
the arteries empty, the veins full and in some places there was some
round cell infiltration while the muscle fibres were larger than normal,
œdematous, homogeneous, somewhat irregular in outline with loss of
the transverse striations, together with marked diminution of the nuclei
of the muscle fibres. The nerves were not examined.

CHVOSTEK in 1892 examined a case in a man of 35 who had arterial
syphilis, who developed a sudden paralysis of the right leg evidently
due to embolism, as the pulse in the popliteal artery was absent while
present in the femoral. The limb was cold, pale, tender on motion, with
flaccid paralysis and absent reflexes. He died three days later and the
thrombosis was found. The crural nerve stained with osmic acid showed
the sheath more deeply stained than normal but not swollen or broken
down. The muscles examined fresh with osmic acid, and hardened in
alcohol, and stained with alum carmine, and alum hæmatoxylin and
carmine, showed loss or indistinctness of the striations, swelling, homo-
geneous, opaque and cloudy fibres, a few of them showing granules
stained by the osmic acid, while the sarcolemma nuclei were absent
and showed hyaline degeneration. Chvostek argued for an injury of
the nerve endings to account for the flaccid paralysis, though interference
with conduction in the nerves and the condition of the muscles them-
selves seems sufficient. Hoynck in 1892 had a similar case of paralysis
of the leg after embolism in a syphilitic woman of 26 with flaccid
paralysis, loss of sensation and diminished reflexes. Sensation returned
partially, gangrene set in and the patient died six days later, the paralysis
having remained flaccid all through. The muscles and nerves were pre-
served in Müller's fluid, and stained by Marchi's method, hæmalum,
and Van Gieson's stain. The nerves showed degenerations; the muscles

a hyaline degeneration with coagulation of contractile substance, loss of striations, and a partial loss of nuclei and in places an increase of interstitial tissue.

HERZOG in 1899 collected 63 cases of traumatic gangrene from rupture of the inner coats of the arteries. In 33 of these cases gangrene followed. Seven died of shock or complicating injuries before gangrene set in. Twenty-three cases showed no gangrene. In these cases the diagnosis was proved by autopsy after death from another cause once, and in the remaining cases by operation and excision of the thrombosed vessel. In two of these cases there remained a firm mass in the muscles, and in the other twenty-one cases there was apparent complete recovery.

These results of thrombosis are important because some cases of Volkmann's paralysis and contracture have followed embolism, as in the cases of Langer and Schloffer, while in Bardenheuer's case of fracture of the clavicle where the arm was tightly bandaged to the side, in Barnard, Dudgeon's and Ward's cases after contusion of the forearm without fracture, in Bardenheuer's case of rupture of the popliteal artery and his case of injury of the leg during operation, in those of Powers and Riedinger after the use of the elastic bandage, we evidently have the condition following disturbances of circulation. These investigations of Chvostek and the cases just quoted it seems to me clearly show that the usual condition after simple interruption of the arterial blood supply is one of flaccid paralysis, and that to produce the contractures seen in Volkmann's paralysis something more than this is required. The same thing is true of the paralysis usually following the use of Esmarch's bandage. Bernhardt, Kobner, and Von Frey—to mention no others—have plainly showed that after the use of an elastic bandage we usually have to deal with a flaccid paralysis, with no contractures in the paralyzed muscles and distinct electrical changes, and this is the common experience certainly in the cases in adults such as I have seen, and the great majority of those in children also.

In Volkmann's paralysis on the other hand we have a condition in which he emphasized certain points, especially in his second article, which was published in 1881. His statement is that the condition follows the use of too tight bandages, particularly in the arm, and more rarely in the leg, that the

paralyses, which are followed very early by contractures in the affected muscles, are ischæmic in origin, and due to the cutting off of the arterial blood supply, while the generally observed and often severe venous stasis seems only to hasten the onset of the paralysis. He thinks that the muscles too long deprived of oxygen die, the contractile substance coagulates, breaks down, is absorbed, and so the process resembles the changes in rigor mortis. Third, he states that another characteristic of this condition is that the paralysis and contracture always come together, or at least almost so, while in paralysis due to nerve injuries the contractures form gradually. Fourth, that another characteristic is that there is great rigidity from the first. Fifth, that this rigidity increases from the contraction of scar-tissue which is formed. Sixth, that the condition is also seen after ligation, rupture, and contusion of blood-vessels, and possibly after extreme cold. Seventh, that the ischæmia is not complete, and so we do not have gangrene, and the severity of the result depends upon the severity of the ischæmia. Eighth, the prognosis depends upon the amount of destroyed muscle tissue. The severest cases he thought were incurable, especially in the hand—while the outlook was better in the leg, as tenotomy there was of more help. Ninth, he maintained that only mechanical treatment helped, and advised stretching in recent cases, while he stated this to be useless in old cases where bones would break or tendons rupture before the muscles would yield.

Volkmann's clinical description of the trouble can in general hardly be bettered, but on certain points the study of the cases of other writers shows that his views must be modified, especially in regard to the treatment of the condition remaining, in which it would certainly seem strange if no advance had been made in forty years.

The condition is one in which after a fracture, usually of the humerus very near the elbow-joint, or of the forearm, and after the application of fixation by one or another method, sometimes with tight bandaging, but by no means invariably so, and at times where there has been no fracture and no band-

aging, there comes on usually within a short time swelling
and blueness of the extremity with more or less pain, and
within a varying time when the apparatus is removed, or within
a short time after this, there is a swelling of the muscles more
marked in the flexors, which gradually shorten so that the
fingers and wrist are held flexed, while in almost every case
the joints are unaffected and the fingers can be extended if the
flexion of the wrist is increased, and the wrist more or less
completely extended when the fingers are allowed to flex, thus
showing that the contracture is greatest in the flexors of the
fingers, while those of the carpus are but little affected.   The
muscles are hard and much more dense than normal, and often
there is a pressure slough or scar which may or may not be
adherent to the deeper tissues.   In a good many cases such
a scar is absent, and these cases and that of Edington, where
it was low down, show that the process in the muscles is not
an extension of the superficial trouble into the deeper tissues.
These are the essential changes, but they by no means complete
the picture, though the remaining conditions vary greatly in
the individual cases.   Some of these are the defects of motion
of the elbow-joint from displacement of bones, or projection
of bony fragments; limitation of supination and pronation,
which is quite frequent, and seems to be due to muscle changes
in the muscles concerned in these movements; and very often
evidences of disturbance of circulation in the extremity, such
as coldness and blueness of the hand or trophic changes such
as a glossy condition of the skin or ulcers and blebs.   In addi-
tion there are frequently seen changes which can only be due to
disturbance of function of the nerves.   These are disturbances
of sensation which are limited to the areas supplied by one or
more of the nerves of the forearm, most frequently only in
that part of the hand supplied by the ulnar nerve, but some-
times that of the median or radial, and occasionally all three
nerves, or paralysis of the small muscles supplied by these
nerves, or atrophy of these muscles.   It is evident in cases
where the injury is in the forearm or to the humerus that this
condition can be due only to injury of the nerves of the arm at

the time of the injury or subsequently. With reference to the frequency of such evidence of involvement of the nerves I have analyzed the published cases, with few exceptions in the original reports and always where these have been accessible to me, and in 61 of the 107 cases included in the table conditions were noted as present which could be produced only by injury of the nerves, and this number is undoubtedly less than that in which the condition was present, as some of the cases are reported without full details.

In regard to the pathological condition present in Volkmann's paralysis there have been numerous reports, and considerable experimental work has also been done. The first examinations of the affected muscles were made by Leser in three of his cases. He describes an increase of connective tissue and loss of the nuclei. Petersen examined the muscles in his case and found similar changes. Bernays is the first American writer to describe the microscopical changes in the muscles. He speaks of the muscle fibres as irregular in arrangement and of unequal thickness, while in some, vacuoles were present. The most characteristic thing was the absence of nuclei, there being often only a little granular detritus in place of the nucleus. The transverse striations of the muscle fibres were lost. In more advanced cases he found round-cell infiltration and increase of connective tissue and finally atrophy and disappearance of muscle fibres. Edington examined an excised portion of muscle and describes increase of connective tissue, irregular, swollen, and hyaline muscle fibres with loss of transverse striations, while in other places the atrophic changes were more marked, and there was increase of sarcolemma nuclei and in places lymphocyte infiltration and beginning connective tissue growth about the blood-vessels. Rowlands simply speaks of much interstitial fibrosis in the muscles. Powers found great hyperplasia of connective tissue, atrophy and fragmentation of muscle fibres, which had lost their nuclei and transverse striations, while others appeared homogeneous and hyaline, but nowhere fatty changes in the muscles. Various writers, where there was no microscopical examination

made, speak of the muscles being firm, harder than normal, yellow in color—and often also of all the muscles being matted together so that they could not be separated or distinguished from one another, as Davies–Colley, Owen, Wallis, Barnard, Schramm, Drehmann, Bardenheuer, Hildebrand, Ferguson, and Bradford in the first case reported in this paper. The changes in the muscles found soon after the injury was received reported by Mannkopf and Molitor have already been spoken of.

Attempts have also been made, not with great success however, to reproduce these contractures experimentally.

The first of these was by Leser, who used rabbits and frogs. The results in the latter were unsatisfactory, as he got paralysis but no inflammatory reaction. In the rabbits in 23 cases he bandaged the leg for three hours and produced a flaccid paralysis with absence of reaction to faradism and swelling of the leg muscles, which became hard. In all of the animals the inflammation subsided in from eight to fourteen days and in three weeks all traces of paralysis had disappeared and he was entirely unable to produce contractures. Lapinsky tied the artery in 10 rabbits and observed changes in motility, sensibility, reflexes, electrical irritability and parenchymatous neuritis, but he produced only flaccid paralyses and no contractures. Bardenheuer's assistant, Lossen, repeated Leser's experiments, bandaging for six hours however, and produced contractures, but in three months these had disappeared, while if the bandage was tighter he got gangrene. From these results Bardenheuer infers that simple anæmia of muscle is not sufficient to produce these peculiar contractures. Hildebrand in his experiments tied the artery, then bandaged the limb and in some cases injured the nerve also. This was done in 7 cases and he produced paralysis with fatty degeneration and atrophy of muscles but not the condition found in ischæmic paralysis.

In reports of operation upon these cases a number of writers speak of the condition found in the nerves. Petersen in 1888 was the first I have found who speaks especially of the condition of the nerves, and also the first to call attention to an occlusion of the arteries in this condition. In his case the radial pulse was deficient and sensation was much diminished in the hand, so that he cut down upon the median nerve, and found this compressed, and that the brachial artery had been occluded. Davies–Colley in one case found both the median

and ulnar nerves small, and purplish in color below the scar-tissue in the forearm. Wallis exposed the median nerve which he found surrounded by fibrous tissue which was adherent to the nerve sheath. Drehmann found the median nerve so embedded in scar-tissue that he was unable to isolate it. Bardenheuer in his third case found the artery thin and empty and the median nerve compressed by scar-tissue, and the same condition in the median and ulnar nerves in his fourth case. Hamilton in 1850 in operating on a projecting fragment of bone found the median nerve stretched over the sharp end of the projection and thinned and got improvement from the correction of this condition. Hildebrand found all three nerves compressed and gray in color in his first case. In the second case the radial nerve was much thinned and compressed while the median was pressed out of place by a projecting fragment of bone and the nerves recovered function after he removed this projection and allowed the nerve to slip to one side. In his third case the median was thinned for a distance of 10 cm., and in the fourth, the median was also small and anæmic. Ferguson found the median and ulnar nerves nodular in places, and smaller than normal. In Powers' case the median and ulnar nerves were found buried in dense connective tissue and thickened. In two of the cases reported in this paper the nerves were found at operation to be involved. In the first case Dr. Bradford found it impossible to isolate the nerves in the forearm, so firmly were they embedded, and in the second case Dr. Cushing found the ulnar nerve flattened and anæmic.

A study of the views of writers upon Volkmann's contracture shows considerable difference of opinion in regard to the mechanism of the production of the condition.

As we have seen, Volkmann and his follower, Leser, thought the ischæmia of the muscles was the essential factor, yet the attempt to reproduce the condition in this way by experiment failed, showing that something more was necessary. Nevertheless there are a number of cases which show that the condition is certainly due to disturbance of circulation. Examples of this are the cases of injuries of arteries such as Petersen's case; Keferstein's fifth case, which did not bleed when stuck; Langer's and Schloffer's cases of embolism; the case of Hoffman;

Kleinschmidt's, in which the pulse was lost; that of Peters quoted by Drehmann, but which I have been unable to find, where no splint was used; one of Hildebrand's cases, where there was a pad placed in the axilla; Riedinger's case where an elastic bandage was left on for two days; and Nolte's, where a tight bandage used for extension was left on. These cases, with those due to embolism or injuries of arteries, where no bandages were applied, show that the disturbance of the circulation is the essential thing.

Wallis in his discussion lays emphasis on the presence of hyperæmia in producing the contractures. Edington in his second article calls attention to the fact that the condition of the muscles is not an extension from the superficial slough which is often present and may leave the skin adherent to the deeper structures, as in one of his cases the scar was low down while the muscles were affected in the upper part of the forearm; and we may add that a number of cases are recorded in which there was no scar from pressure slough. Bardenheuer in his discussion of the etiology emphasizes various points. He thinks it is necessary to have an injury of the intima or media of the artery, but that venous stasis also is important, and shows by some of his cases where this was absent that the inflammatory reaction in the muscles was much less. He argues that the reason why these contractures are more frequently found in children, while injuries of arteries in adults usually result in more or less extensive gangrene, is due to the greater ease and rapidity with which collateral circulation is established in children. Hoffmann in his case where the brachial artery was injured found well marked evidence of collateral circulation about both the internal and external condyles.

Hildebrand thinks the changes in the muscles the most important factor in the formation of these contractures, but argues for involvement of the nerves also. He emphasizes the fact of pressure preventing the formation of collateral circulation and the frequency of injury of the arteries and thrombosis. He also states that where there has been no bandage used there is always effusion of blood to prevent the collateral circulation. He considers the predominance of the affection of the flexor muscles as due to the fact that the median nerve is more often injured, while in fact more cases show involvement of the ulnar than of the median, and Oppenheim in his text book speaks of injury of the ulnar nerve as the only condition likely to be confounded with Volkmann's contracture. Hildebrand argues for a momentary crushing of the nerves, and later speaks of the frequency of continuous pressure upon the nerves from scar tissue, and says that rupture of nerves is rare. He states however that paralysis from nerve injury does not necessarily belong to the picture and that in most cases this is of gradual onset later, both of which statements I can confirm, the first in particular by a case recently seen which is not included in this paper in which the changes were limited practically entirely to the flexor profundus digitorum, with marked contracture, while there was not the least evidence of involvement of any of the nerves of the fore-

arm. Hoffmann also argues for the involvement of nerves as well
as arteries.   Kleinschmidt thinks that the venous stasis is essential
for the production of these contractures.

It seems to me a strong argument for the primary condition
being dependent upon circulatory disturbances, and probably
an anæmia of the muscle with obstruction to the venous
circulation also, that cases have occurred from embolism,
and especially such cases as that of Nolte, where a bandage
was applied to the arm for extension and left on, compressing
the arm severely, and Riedinger's second case, where a girl
of 15 crushed her finger and an elastic bandage was applied
to the upper third of the forearm and left for two days on
account of the hemorrhage, where the subsequent atrophy of
the muscles stopped where the bandage ended, and the hand
muscles where no bandage had been applied remained normal
also.   These are clearly cases produced by disturbance of
circulation and probably by this alone.   While it may be im-
possible to say that nerves are not at all involved in the pro-
cesses which produce the changes in the muscles, the facts seem
to me to show that if this is the case it can be only the terminal
muscle branches that are necessarily so affected, and that this
is of secondary importance, and such facts as the involvement
of part of a muscle only by the connective tissue formation
with a good response of the remaining portion of the muscle
to electrical stimulation as I have seen it, in my opinion shows
that the nerve involvement in the primary process is not a
necessary factor.   On the other hand secondary affection of
nerve trunks from involvement in connective-tissue overgrowth
is frequent.   Disturbance of sensation in the hand can only
be produced in this way, especially when it is limited to the
area of skin corresponding to the distribution of one of the
nerves of the arm.   The same thing is true of atrophy of the
small muscles of the hand, and the presence of the reaction of
degeneration in these muscles, a positive evidence in these
cases of involvement of the nerve trunks, as destructive inflam-
matory processes in muscle in itself can produce only dimin-
ished or absent electrical reaction.   Paralysis of these hand

muscles can only be due to nerve involvement and this point is the one most frequently overlooked. One must remember that the movements of the fingers performed by these muscles are those of abduction and adduction, flexion of the first phalanx, and extension of the two distal phalanges, and that paralysis of muscles in the forearm while they may limit these movements cannot cause their entire absence. In case of paralysis of these small muscles we get from contraction of the opponents an extension of the first and flexion of the second and third phalanges. This flexion would of course be favored by the contraction of connective tissue in the flexor sublimis and profundus digitorum, but this formation of contractures in the flexors cannot produce the extension of the first phalanx which was noted in many of the reported cases. If then we assume the presence of one of these conditions as evidence of involvement of nerve trunks we find that this existed in 62 of the 107 cases contained in the table, and probably was present in a portion of the other cases, as in many papers the details of the examination were not given.

In regard to other factors in the cases of Volkmann's contracture a study of the reported cases shows the following things. Of the 107 cases included in this paper the sex was stated 89 times, of which 62 were males and 27 females, the predominance of males being undoubtedly due to their greater liability to accidents.

The predominance of children is very striking. In 18 cases the age was not stated, and in 2 it was simply stated that they were adults, and in 6 children. Of the 81 cases where the age was given the youngest was 2 years and the oldest 50, but of these 81, 66 were 15 years or less, and 62 were 12 or less.

2 years	1 case	11 years	0 case	21 years	1 case
3 years	2 cases	12 years	6 cases	24 years	1 case
4 years	5 cases	13 years	1 case	25 years	2 cases
5 years	10 cases	14 years	1 case	30 years	1 case
6 years	13 cases	15 years	2 cases	32 years	1 case
7 years	7 cases	16 years	1 case	33 years	1 case
8 years	6 cases	17 years	1 case	34 years	1 case
9 years	5 cases	18 years	1 case	40 years	1 case
10 years	7 cases	20 years	2 cases	50 years	1 case

The most frequent injury was fracture and the marked predominance of this at or near the elbow-joint with its great liability to injury of the brachial artery to which Bardenheuer has especially called attention is very striking. Of these 107 cases 5 were in the leg, and 102 in the arm. The injury consisted in:

ARM.

Fracture of the arm, region not stated............	5 times
Fracture humerus, part not stated................	4 times
Fracture humerus, middle	1 time
Fracture humerus, above condyles	28 times
Fracture humerus, into elbow-joint..............	15 times
Fracture forearm, middle or upper...............	24 times
Fracture forearm, lower	5 times
Fracture radius	5 times
Fracture forearm, region not stated..............	2 times
Dislocation both bones of forearm................	2 times
Fracture clavicle, and tight bandage.............	1 time
Contusion of forearm	6 times
Elastic bandage	2 times
Septic infection of arm..........................	1 time
Embolus of arm	1 time

LEG.

Splint for fluid in knee..........................	1 time
Fracture of both bones of leg....................	1 time
Rupture of popliteal artery.......................	1 time
Injury of leg at operation.......................	1 time
Embolus	1 time
Total...................	107 times

The treatment of the primary injury was as follows (but often it was stated that the splints and bandages were lightly applied, and at times that the splints were of pasteboard or of similar character):

Splints	52 cases
Splint, in cases of stab-wound or in infection......	2 cases
Plaster-of-Paris	28 cases
Apparatus	1 case
Bandage	2 cases
Sling	1 case
Quiet	3 cases
Not stated	18 cases
Total.................	107 cases

As to the frequency of mention of the chief symptoms I have found as follows: Pain was stated to be present 32 times; muscles tender 1 time, though this was also found in many of the cases where there was pain present, and this was especially noted as absent 7 times; swelling, immediately after the injury, was noted 50 times. The pulse was noted as absent or much diminished 10 times, and once it was stated that the hand did not bleed when stuck. A slough or a scar from a former slough was present 37 times. Various trophic changes, showing disturbance of circulation, such as coldness, cyanosis, shiny skin, ulcers on the fingers, or blebs, were noted 37 times.

Symptoms of involvement of the nerves of the forearm were present in 62 of the cases, nearly 60 per cent. of the whole number, and these were as follows:

SYMPTOMS OF NERVE INVOLVEMENT OF FOREARM.

Disturbance of sensation in the hand.............. 34 times
Atrophy of small muscles of the hand............. 27 times
Paralysis of the small muscles of the hand......... 36 times

CHANGES OF ELECTRICAL REACTIONS IN THE HAND.

Loss or diminution to faradism.................. 24 times
Loss or diminution to galvanism................. 10 times
Reaction of degeneration......................... 10 times

CHANGES OF ELECTRICAL REACTIONS IN ARM MUSCLES.

Loss or diminution to faradism.................. 26 times
Loss or diminution to galvanism................. 14 times
Reaction of degeneration......................... 6 times

When we turn to the treatment of this contracture we find several interesting facts. As we have seen, Volkmann advocated stretching the contracted muscles under an anæsthetic, but looked upon the severe cases as incapable of improvement. Keferstein in 1893 reported a number of cases treated by this method of stretching, and a number of his cases were looked up by Kaempf, whose paper was published in 1897, or only four years later, and cases 1, 2, 3, 4 and 5, seen one or more years after the treatment, were unimproved, the contracture having been unrelieved or having returned. The first operations reported consisted in chiseling away pro-

jecting portions of bone, and improving the position of the
fragments. Petersen, in 1888, seems to have made an attempt
to free the compressed nerves by operation, and obtained considerable improvement, but his report attracted little attention.
Hildebrand in his article in 1890, and Niessen in the same
year, reported considerable or great improvement from gradual
stretching of the contractures, and this seems to have given
more permanent results than the forcible procedure under an
anæsthetic, especially when supplemented by massage and
electrical treatment. Martin in France in 1903 also advocated
the use of a device to exert a continuous pull upon the muscles,
but also used resection of the bones, and Lycklema and Nyeholt in 1904 advised the same procedure, combining it with the
operation of lengthening the tendons, while Jones of Liverpool relies greatly upon continued stretching of the muscles.
Davidsohn, writing in 1891, seems to have been the first to report results from attempts to improve the contractures by
operation, having lengthened the flexor tendons, and getting
good extension of the fingers and moderate motion in them,
though no improvement in the atrophy of the muscles of the
hand supplied by the median nerve, for which he attempted
no relief. Page in England, writing in 1900, practised lengthening the tendons, and was followed in 1901 by Littlewood,
both apparently not knowing of the previous work of Davidsohn, but Davies–Colley in 1898 had done a tenotomy, after
which there was no active flexion of the fingers, though there
was of the thumb. These men were followed in England
by Wallis, Barnard, Edington, Ward, Rowlands and others.
The first report of an operation in America that I have been
able to find was one of tendon lengthening reported by Galloway in 1902.

Garré in 1895 appears to have been the first to resort to
resection of the bones of the forearm, and obtained an improved position of the fingers. He was followed in 1896 by
Henle. Dunn in England, in an article published in 1897,
had advised an operation, but at the time of writing, it had
not been done. Johnson, independently of the German work-

ers, reported cases in 1898 treated by this method. Owen, writing in the same year, spoke of the operation of division of the tendons giving an unsatisfactory result, and thought resection the most promising operation, and he reported cases treated by this operation combined with tendon lengthening in 1900. Bernays wrote the first article upon this subject that was published in America so far as I have been able to find, and though he speaks of two cases of his own he did not report them, evidently thinking the condition due to carelesness of the surgeon, but he thought that resection was the only operation likely to prove useful. Dugeon in his second article, published in 1903, gives the same opinion. Other advocates of this procedure are Willmann and Kob, both writing in 1905, Huntington in this country in 1907 and Kleinschmidt in Germany in the same year.

In 1904 came the first reports from Germany of repetitions of the operation of lengthening tendons, when Schramm reported a case. Drehmann, writing in the same year, speaks of this operation having been done by Alapy, whose article I have been unable to find. Drehmann however did rather more than the simple tendon operation, as he attempted (though not successfully) to dissect out the median nerve, which was embedded in scar tissue. He separated the muscles of the ulnar side of the forearm from the artery and each other, and by incisions of the contracted muscle and scar tissue lengthened them until he was able to extend the fingers, and then sutured these muscles to the healthy flexor profundus. This operation gave marked improvement with good use of the hand except of the thumb, evidently due to the involvement of the median nerve, which he had been unable to free. This is the first report of any operation in the nature of a myotomy which I have been able to find, but I wish to call attention to the fact that this was practically what was done by Bradford in 1901 in the first case reported in this paper. Hoffmann and Wollstein in Germany returned to tendon lengthening. Bardenheuer in a case reported in 1906 dissected off the contracted muscles and freed the nerves, and Hildebrand in the

same year reports cases in which he dissected out the compressed nerves in the forearm, and in one case placed the nerve over the sutured muscles, suturing the fascia over the nerves, and in another case he resected a portion of a nerve. Ferguson in America in 1906 and Powers in 1907 also freed the nerves. Quinby in 1908 at an operation on one of these cases where there were symptoms of compression of the ulnar nerve stretched this nerve and placed it above the condyle, with relief of the symptoms produced by the compression of the nerve, and at this time he did not know of the case of which I am going to speak. The second case reported in this paper, where Cushing, of the Boston Children's Hospital, dissected out the ulnar nerve and placed it in front of the condyle, was done in 1904, thus antedating by several years similar procedures done independently by Hildebrand and Quinby.

Because of the various degrees of involvement of muscles, in many cases supination and pronation being limited by these changes, while in others only a moderate destruction of the flexor sublimis may be present, as well as the fact that disturbances of circulation and trophic changes vary greatly in amount or may be absent, to say nothing of the possible complication from secondary involvement of nerve trunks, it is difficult to analyze the results from the various forms of treatment adopted in different cases. So far as this can be done the reports are as follows:

FROM CASES TREATED BY SUCH MEANS AS STRETCHING OF CONTRACTURES WITH OR WITHOUT THE USE OF MASSAGE AND ELECTRICITY, THE RESULTS WERE GIVEN AS:

No improvement .... 8 cases
Slight improvement .... 9 cases
Improved .... 19 cases
Good .... 4 cases
Results of treatment not given.................. 14 cases
Tenotomy .... 2 cases

TENDON LENGTHENING.

Not stated .... 5 cases
Slightly improved .... 2 cases
Improved .... 11 cases
Good .... 4 cases

RESECTION OF BONES.

Non union .... 2 cases
Not stated .... 1 case
Slight improvement .... 1 case
Improved .... 7 cases
Good .... 3 cases

FREEING NERVES.

No improvement .... 2 cases
Slight improvement .... 2 cases
Improved .... 5 cases
Good .... 4 cases

MYOTOMY.

Improved .... 2 cases

AMPUTATION: *One case.*

The frequency of this condition is probably greater than the published cases would indicate, many cases not being put upon record because of the widespread impression among the profession that it is due to the improper application of splints, as indeed is sometimes the case. For instance, Ward states that he thinks he has seen an average of one case a year from 1877 to the time of this writing (1902),—that is twenty-five cases,—though he reports but two. Rowlands speaks of having had seven cases, and knowing of four unpublished ones, where resection was done. Bernays thinks the condition frequent. There have been two or three cases at the Children's Hospital which I have not included in this paper simply because I did not happen to have the opportunity of examining them myself. One of these Goldthwait operated upon, lengthening the tendons, with a fairly good result. Goldthwait also has told me in a verbal communication that he has treated two or three other cases with good results by the method of gradual extension of the fingers and wrist by means of apparatus advocated by Jones of Liverpool at the meeting of the American Orthopædic Association in Washington in 1907. On the other hand Schramm, in his article, states that the case he reported was the first one he had seen in nineteen years. Probably the experience of surgeons varies with the number of cases

of children's affections they see, and partly also with the surgical skill and judgment of the practitioners in their neighborhood,—the number of " natural bone setters."

The relative merits of different procedures must vary with the severity of the case and the particular features present, and this is true both of the primary trouble, and of the secondary involvement of the nerve trunks.   I have seen nerves recover under treatment by electricity and massage, as well as finding instances of this among the published cases, while in other cases these measures have proved of no avail.   The same statement is true of the various methods of extension, though stretching the contracted muscles under an anæsthetic is often followed by marked inflammatory reaction and has proved to be of little or no value, the contracture usually returning quickly.   The method of gradual extension by passive movements or apparatus is often all that is necessary, especially when the contracture is confined to the flexor sublimis digitorum.   In the severe cases, and those where there is limitation of pronation and supination, a cutting operation seems to offer the most chance of a good result.   Resection of the bones, while it corrects the deformity from the contracture, must weaken the extensors and has the not inconsiderable danger of non union, and often gives no increased usefulness to the crippled hand.   The process of lengthening the tendons has given better results on the whole than resection, but is open to the objection of the greater liability to infection from the great number of sutures required, and the great difficulty of afterwards breaking up the numerous adhesions within the tendon sheaths, to say nothing of the difficulty and consequent length of the operation, a thing to be considered in young children.   On the whole myotomy or dissection of the affected muscles from their attachments and suture in other positions as has been done by Drehmann and Hildebrand and by Bradford seems the most promising procedure in the severer cases requiring operation, while for the compression of nerve trunks there seems no need to despair, at least in cases where they can be identified, as Owen does when he remarks in his article that the question of

nerve injury is an interesting one, but that he does not know where to look for it, nor what to do for it if he found it. The work that has been done since this was written in 1898 shows that the freeing of nerve trunks, the placing them away from the contracting muscles under the skin, where I may say that in our case with Cushing they have caused not the slightest inconvenience, and at times the resection of a portion of a nerve and its suture, or in some cases as has been suggested by Quinby by a longitudinal disassociation of the nerve fibres, if there is evidence of scar tissue within the nerve sheath, such as has met with success in the hands of Delbet and Babcock, offers us the choice of methods of great promise.

In all cases in which operative measures are decided upon the importance of after treatment can hardly be exaggerated. This should be by means of passive and active movements, massage, and in many cases stimulation of the muscles by the faradic current, and these measures must often be continued for many months in order that the full benefit of the improved conditions from the operation may be obtained. If this is not done, in many cases the only result from operation will be a greater range of passive movement with no improvement in the functional use of the limb.

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OPERATING UPON THE CRANIAL VAULT.

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THE achievements of the last few years in the realm of cranial surgery have awakened increasing attention to the development of a more satisfactory method of entering the skull. The crucial question is to lift a goodly sized osteoplastic flap with no injury to the sublying tissues and to prevent the sudden hemorrhage that all too frequently jeopardizes the success of the operation and even the life of the patient. The pioneers in this practically new field are realizing the inadequacy of what might be called the hand instruments and are turning to the mechanically driven instruments. Of these the only ones of importance are the spiral osteotome and the circular saw.

The spiral osteotome, while a valuable instrument, possesses certain defects of considerable moment. The inside guard fixed to the drill is incapable of adjustment to permit of preliminary separation of the dura, but must be forced along only as the side cutting drill cuts the way. The drill clogs quickly, and is especially troublesome in hard and thick skulls. It also heats quickly, a source of injury to itself as well as the tissues concerned. To be practical the drill must be so large, making thereby a proportionately wide incision, that an appreciable degree of sinking of the bone flap occurs after reposition. This feature is especially undesirable in the operations for decompression. It is hardly to be denied that the circular saw, possessing certain qualities of inherent superiority, is the desirable instrument if it can be efficiently controlled. The principles of my instrument (Fig. 1) by which this has been accomplished have been given in detail in earlier publications,[1] and it is not necessary to repeat them. One point that seems to have been misunderstood is the advantage of having the saw, the handle, the arm and the eye of the operator all in

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[1] Jr. A. M. A., March 4, 1905; Annals of Surgery, Aug., 1906.

line in making the section. This is the natural method used by the carpenter and all mechanics. It gives a flexible wrist, a better use of the sensitiveness of the fingers, an easy and full control that is not accorded to the same degree by a saw at right angles to a slender handle.

Turning to the real purpose of this paper it is my aim to state a few details of technic that show the nicety and certainty with which the bone can be cut, with absolute protection to the sublying tissues. After making the two preliminary openings, preferably at the thinnest and the thickest angles of the contemplated flap, the thickness of the skull is ascertained. The outside guard is then set to cut through the greater portion of

FIG. I.

the thickness so determined. The side being operated upon is then quickly cut to this depth. I prefer the use of the outside guard at this time because it leaves but a small portion of the inner table to be cut when using the inside guard. While this procedure is not essential it does permit, by a little, a greater degree of attention to the safety of the dura. To make the final section the inside guard is attached to the handle. Now keeping the saw *with the power off* and *away from the bone,* the guard is carefully insinuated along the inner wall of the skull. Sole attention is thus given to the thorough dissection of the dura and blood-vessels away from the inner table *before* the saw is brought into play. When this is accomplished the power is turned on full, the saw is lowered into the cut and the incision is made down to the guard. Then drawing back-

ward the incision is completed throughout the length to which the guard has penetrated. The saw is now lifted, the guard is advanced, the dura is further dissected away, and the operation repeated as before. After cutting the three sides the remaining isthmus is broken up with chisels as is usually done.

The operator should have one assistant devoting his attention to the motor. One hand should hold the controller, using the current as indicated. The other hand loosely supports the cable in the palm, thus removing all side drag from the instrument and by keeping the cable at an easy curve increasing its effectiveness. The cable is preferable to the belt drive because it can be sterilized more satisfactorily. Either, however, can be used for the purpose. A hand-motor could be used where the electric current is not available. For decompression work the circular saw is the instrument par excellence. Whereas other devices permit sinking of the flap, with the saw the flap is actually elevated when replaced. Should one desire a perfect replacement, this can be done by snipping off the spurs on the fractured side of the flap sufficiently to accomplish the purpose.

THE SURGICAL TREATMENT OF INTERNAL HYDROCEPHALUS.*

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In internal hydrocephalus, from whatever cause, the free circulation of cerebrospinal fluid is mechanically interfered with. For the cure of this condition but two courses are open: either the free circulation of the fluid through its normal channels must be restored by removing the obstructive cause, or a new channel must be provided by which the imprisoned fluid can find its way to the subarachnoid space or be carried to a part of the body where its continuous absorption can take place.

The choice of which of these two courses to pursue will depend upon a study of the individual case in regard to the etiology and location of the obstruction. Before the results of the studies of Leonard Hill were made known (to whose studies concerning the pathology and physiology of the cerebral circulation it is owing that to-day we can approach the cure of internal hydrocephalus with something approaching certainty) many unsuccessful attempts were made to get rid of the fluid. Single and repeated punctures of the lateral ventricles were made even so far back as the Roman era. Aspiration with injections of iodine have been employed in some cases. In 1891 Quincke advocated single and later repeated lumbar puncture, withdrawing a small amount of fluid each time. In the same year Keen employed continuous external drainage in a single case; an interesting feature of this case being that the convulsions that followed the too rapid drainage of the fluid were allayed by the distention of the ventricle with warm boric acid solution. None of these methods met

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with success. Subsequent to Hill's investigations, attempts at surgical treatment rested on a firmer scientific basis. In 1898 Parkin trephined the occipital bone one inch below the superior curved line and to the right in order to free basilar adhesions and open the fourth ventricle; of four cases, two recovered. In March, 1898, Bruce and Stiles reported a case much improved after trephining the occipital bone in the median line just above the foramen magnum, tying the sinus in the falx, opening the dura and re-establishing the communication of the fourth ventricle. In the same year Mikulicz established drainage between the lateral ventricle and the subaponeurotic tissues of the scalp by means of a gold tube. The case died in six weeks. In a second case the same operator established drainage between the lateral ventricle and the arachnoid space by means of a drain of glass wool. In this case the disease was arrested. In October, 1898, Southerland and Cheyne reported two cases in which ventriculo-arachnoid drainage was established by means of catgut. In both cases the distention was relieved. One case died in three months from basilar meningitis; the second case was living six months after similar drainage was performed on the opposite side and was much improved. In 1903 Brewer operated on three cases, turning down an osteoplastic flap, opening the dura and forcing rubber tissue into the most dependent portion of the lateral ventricle, thus establishing ventriculo-arachnoid drainage. These cases died; one which lived six weeks showed a three-inch decrease in the circumference of the skull. In 1903 Nicholas Senn reported a case of sub-aponeurotic drainage in which the circumference of the head decreased two inches, the child dying on the ninth day. In 1904 Taylor established ventriculo-arachnoid drainage in six cases with a bundle of chromic catgut surrounded with cargile membrane: two cases were benefited: one markedly, physically and mentally, the other not so marked at the time of report as to afford much encouragement of subsequent improvement; three died as a result of the operation and one of intercurrent disease ten weeks after the operation. In

1908 Cushing, in a preliminary note, mentions twelve cases in which he established permanent drainage between the spinal canal and postperitoneal connective tissue, using a silver tube and first determining the continuity of circulation between the lateral ventricles and the spinal canal. Both laparotomy and laminectomy are included in the operation. Without going into detail he reports a considerable measure of success. He also states that two previous attempts have been made to drain the subarachnoid space into the surrounding tissue, one by Quincke, who made a blind incision following lumbar puncture, the other by Essex Wynter, by performing laparotomy for this purpose.

From a review of the foregoing methods and a consideration of the etiological factors it is clear that the chances for success in treatment depend entirely on employing an operation fitted to the individual case. Should the history of a case permit of the diagnosis of tumor so located as to occlude the fourth ventricle, following the demonstration of the arrest of circulation between the ventricles and spinal canal, a basilar exploratory operation is indicated even to the extent of removing half of the cerebellum, should this prove necessary in order to reach the tumor (Frazier). Should the tumor be irremovable the operation will have helped the patient temporarily by relieving pressure. Later, if desirable, ventriculo-arachnoid drainage may be employed. Following meningitis adhesions may result at the base, shutting off the foramina of Magendie, Key and Retzius, thus causing distention of all the ventricles, or adhesions about the cerebellum may close the lower end of the fissure of Sylvius or ependymitis may close one or both lateral ventricles, or adhesion may occur at all these points. The first step in such cases would consist in determining whether or not there existed a communication between the ventricles and the spinal canal. If such is found to be the case Cushing's operation of connecting the spinal canal with the postperitoneal connective tissue should be performed. If such is not the case, ventriculo-arachnoid drainage by Taylor's method may be done. If doubt is felt as

to the causative lesion an exploratory basilar operation may be performed and the causative lesion removed, if possible, or if not Taylor's operation done later.   Before performing an exploratory operation on the base the tension of the fluid in the ventricles should be considerably and slowly lowered by preliminary puncture, for the sudden lowering of the tension by the escape of the fluid through a basal dural opening after raising up the cerebellum and separating the adhesions is apt to prove fatal.   Following along the lines of thought set in motion by Keen's case, previously quoted, it may add an element of safety if, subsequent to suture of the basal dura, saline were introduced into the lateral ventricles to equalize the pressure of blood in the blood-vessels.

CASE I.—L. S., male, aged 8 months, parents healthy; sister aged 4 years healthy.   Was a full term baby; instrumental delivery.   When the child was 11 weeks old, the mother thought the head disproportionately large and consulted various physicians. The child was given mercury and potassium iodide for several months without effect.   The head continued to enlarge, and the eyes became crossed.   The child nursed regularly and except for the increasing size of the head, the internal strabismus, and the lack of the usual mental development was healthy.   The case was referred to me April 26, 1908, by Dr. Burton Harris.   My examination showed a well-nourished strong baby, without paralysis, who supported his enormous head well.   The head measured 24½ inches in the fronto-occipital diameter.   The parietal bones were separated from each other and from the frontal and occipital bones.   The baby did not notice its surroundings nor grasp with its hands.   There was marked internal strabismus.   Operation was advised.   On April 28, at the German Hospital, the left lateral ventricle was tapped at Kocher's point and 30 ounces of fluid was drawn.   This resulted in a falling in of the parietal bones but the frontal and occipital bones were not much affected, the fronto-occipital diameter being reduced but one inch.   A compressing and supporting dressing was applied.   Examination of the fluid showed it to be faintly alkaline, with a trace of albumin and a large amount of chlorides. The fluid rapidly reaccumulated and at the end of forty-eight

hours the head had assumed its former proportions. A hollow
needle was now introduced into the left lateral ventricle at
Kocher's point and a second needle into the spinal cord between
the fourth and fifth lumbar vertebræ in order to determine if
there existed a communication between the spinal canal and the
ventricles. Closure of the open end of the needle in the ventricle
caused a faster flow of fluid from the needle in the spinal canal.
Only an ounce of fluid was withdrawn by the spinal needle in
order to avoid the possibility of an accident such as happened in
one of Cushing's cases, when the withdrawal of a large amount of
fluid by spinal puncture resulted in a hernia of the brain into the
foramen magnum with subsequent death. Two days later under
warm ether anæsthesia the abdomen was opened, and the body
of the fourth lumbar vertebra trephined, first displacing the aorta
to the right, a specially small quarter-inch trephine on a French
drill handle being used. On removing the small button of soft
bone, spinal fluid in a good-sized jet immediately flowed from
the opening. The abdomen was then closed. The after course
was uneventful. The head under compression with adhesive
plaster decreased to 22½ in., but by the tenth day had increased
to 23¼ inches. Tapping of the ventricle reduced the fronto-
occipital diameter to 22⅝ inches; 15 ounces of clear fluid were
removed. The vertex of the head did not present the dome-
shaped appearance that was so pronounced before the operation.
The internal strabismus was not so marked but still present. Dis-
charged from the hospital May, 1908. On June 19, 1908, the ven-
tricle was again tapped, as the head had increased to 24½ inches,
and there was considerable tension at the anterior fontanelle.
The strabismus was again marked. Eleven ounces were with-
drawn.

A second operation for the purpose of introducing a silver
tube to permanently connect the peritoneal and spinal cavities was
advised. This was done September 8, 1908. Head measurement
24 inches. Under warm ether anæsthesia the abdomen was
opened, the intestines displaced, the peritoneum over the aorta
at its bifurcation incised and the aorta retracted to the right.
No trace of the former trephine opening was seen. The body of
the fourth lumbar vertebra was trephined into the spinal canal as
shown by the escape of the spinal fluid, and the female half of a
silver spinal-drain was introduced. (The spinal-drain consisted

of two portions, one fitting snugly within the other, each ¾ inch long, ¼ inch calibre with a ⅛ inch flange.) A laparotomy sponge was placed in the wound and the patient turned back uppermost. The spines of the third, fourth, and fifth lumbar vertebræ were exposed and the third and fourth removed with part of their laminæ. The cord, quite well marked, was retracted with an aneurism needle and the male half of the drain introduced—one hand in the abdomen greatly facilitated this. It was not necessary to remove much of the laminæ as by using retraction the canal could be quite well exposed. The wound in the back was closed. The tube was inspected through the abdominal wound and seen to be draining. The abdominal wound was closed. The after course was uneventful. September 12, 1908, head measurement 23⅞ inches; September 24, 24 inches. The strabismus was much less marked and the child evinced interest in its surroundings. There was an entire absence of tension in the fontanelles. The top of the head became flattened. Discharged September 27, 1908. Final examination December 1, 1908, showed: No return of strabismus; child active, mentally and physically; vertex flat; no tension; fronto-occipital measurement 24 inches. The disease seems to be arrested. The child is normal for its age in every way except the size of the head. This, however, has not increased in the past two months.

CASE II.—J. H., male, aged 5 months, parents syphilitic; referred by Dr. John Horni. The child was well until 2½ months old (but was not bright), when the mother noticed that the head seemed to be larger than normal and the eyes rolled from side to side. The head continued to increase in size. When seen by me September 7, 1908, the patient presented the typical appearance of hydrocephalus; there was nystagmus; no paralysis; the baby was very stupid. Operation was advised and the patient was sent to the Methodist Episcopal Hospital. On September 9, 1908, free communication between the ventricles and the spinal canal was determined in the usual manner. September 14, the lateral ventricles were tapped and 10 ounces of fluid withdrawn. On September 17, Cushing's spinal peritoneal anastomosis with a silver tube was done. September 18, 1908, the head had decreased ¾ of an inch; September 20, the head had increased in size to 20¼ inches. September 11, spastic flexion of the forearms and spastic extension of the feet were noted. September 22, the

spastic condition continued.   This was not relieved by ventricular
puncture and removal of 3½ ounces of fluid.   September 24, as
the spastic condition still persisted and the baby was semicomatose,
further operation was undertaken as a last resort.   Puncture of
the spinal canal above the tube level not being followed by any
fluid, it was thought perhaps the pressure of the fluid in the skull
had crowded the cerebellum into the foramen magnum and so
shut off the free communication which had been previously
demonstrated.   The ventricles were punctured and 12 ounces
of fluid withdrawn.   Cushing's decompression operation was done
on the base of the skull, removing half of the foramen magnum.
The dura was incised, and the following condition disclosed; there
was no obstruction of the foramen magnum; there was a de-
ficiently developed brain held to each side of the skull by the
lining of what would under normal conditions have been the walls
of the ventricles; the cerebellum was represented by two masses
about the size of a hazelnut to either side and several inches from
the foramen magnum; there was no connection between the two
halves of the brain save at the medulla; this large central cavity,
representing all the ventricles, was smooth and contained about
20 ounces of fluid, part of which escaped through the opening
in the dura.   It was decided that nothing further could be done
as the stoppage was in all probability a plastic inflammation of
the spinal cord and membranes at some point above the tube.
The wound was closed.   The patient's condition continued bad
and death intervened ten hours later.   The fact of particular
interest in this case, is the occurrence of an adhesive inflammation
above the tube in the spinal canal taking place some days after
operation and preventing drainage.   This has not hitherto been
noted as a complication in these cases.

CASE III.—P. C., male, aged 9 months (referred by Dr.
Aronson), was well until 6 months old when he suffered an attack
of cerebrospinal meningitis.   On examination the head was found
enlarged, fontanelles distended, head measurement 18⅜ inches;
baby apathetic, poorly nourished and unable to support the head.
Operation advised and case sent to Methodist Episcopal Hospital.
On September 21, 1908, it was determined in the usual manner
that there existed no communication between the ventricles and
the spinal canal.   Several ounces of fluid were removed from the
lateral ventricle.   September 24, Cushing's basilar decompres-

sion operation was performed with the idea of freeing the adhesions around the cerebellum and base which interfered with the free circulation of cerebral fluid. The condition was demonstrated, the adhesions below, in front, and to the lateral aspects of the cerebellum freed, a probe passed along the fissure of Sylvius, and a free discharge of cerebrospinal fluid obtained. The dura was sutured and the soft parts about to be closed when the patient expired without warning.

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OPERATIONS INVOLVING FREE OPENING OF THE THORAX.

INFLATION OF THE COLLAPSED LUNG WITH OXYGEN AT THE MOMENT OF CLOSING THE CHEST CAVITY AFTER OPERATION.

BY A. E. ROCKEY, M.D.,

OF PORTLAND, OREGON.

THE simplicity and effectiveness of this procedure was so well demonstrated in the following case, that it is reported with the belief that its further use may be of value in operations involving the opening of the thorax.

CASE.—*Sarcoma of wall of thorax; excision of tumor-bearing portion of thorax wall and diaphragm; successful attempt to inflate collapsed lung with oxygen; recovery.*

Man aged 52 sustained a fracture of the middle of the tenth rib on the right side a year ago. After several months a growth was noticed over the site of the injury. It increased steadily and was treated by various domestic applications until it attained the size of a goose-egg, when he consulted a physician who diagnosed it sarcoma, and sent him to me for operation.

Colonic anæsthesia was given by the oxygen-ether method of Cunningham as modified by Leggett and used at the Roosevelt Hospital.

Warned by one nearly fatal experience of over-etherization at the time the change was made from the inhalation anæsthesia to the rectal, I adopted the recently-announced plan of Klapp, the sequestration of unetherized blood in the lower extremities by placing elastic bands about the upper part of the thighs before etherization is commenced. It proved fortunate, too, that we had this reserve, for after the beginning of the operation and before the chest was opened the patient became cyanosed, breathed badly, and his pupils were widely dilated.

Loosening of the bands to liberate the unetherized blood relieved the condition at once, and the rectal anæsthesia was continued with caution, using very little ether, and with entire satisfaction to the conclusion of the operation.

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The tumor, which on the inside was larger than a man's fist, was excised with the entire thickness of the chest wall, including an elliptical piece of skin over the most prominent part, about six inches of the eighth, ninth, and tenth ribs, with the pleura and a portion of the diaphragm about two inches wide in the centre and six inches long, and the adjoining part of the abdominal muscles and the peritoneum. The peritoneum over the inner side was lightly adherent to the liver by a plastic adhesion that did not bleed when it was detached.

In closing, the diaphragm was firmly sutured to the chest wall with a continuous suture of heavy catgut. Before the last inch of the incision was closed, the tube from the oxygen cylinder was introduced into the nostril with only an intervening pressure-regulating bulb like the second bulb on a Paquelin cautery.

The other nostril and the mouth were closed by the hand and the oxygen turned in, with the result that the residual air in the pleural cavity hissed through the unclosed part of the incision until the lung was filled. Finger pressure by the assistant on the under surface of the diaphragm closed the pleural cavity until the remaining stitches were introduced.

The inflation of the lung required only a very short time, seemingly less than a minute. Immediately after the conclusion of the operation normal breath sounds were heard over the entire lung, and there were no physical signs of pneumothorax.

There were several features present in this operation that are worthy of special mention. Opening of the right chest cavity with consequent collapse of the right lung was not attended by any disturbance due to embarrassment of respiration, which was, of course, subsequently carried on entirely by the left lung.

How much the oxygen used in the rectal anæsthesia contributed to the general oxygenation of the blood must be left to the surgical laboratories to determine by animal experimentation.

As the chest cavity and the abdominal cavity were open simultaneously, and as colonic anæsthesia was used, the inflation of the colon was readily observed. The distention was moderate and at no time did it give trouble by protrusion into

the field of operation, being readily retained by a large moist gauze pad held under the hand of an assistant.

The inflation of the lung with oxygen was done without any attempt to prevent the entrance of gas into the stomach, either by intubation of the larynx or introduction of a tampon into the œsophagus.

It is, of course, self-evident that without such aids, if the inflation had been continued, the stomach would also have been distended.

It is of important interest to note that the lung was filled, pushing the air out of the pleural cavity before distention of the stomach occurred. This simple and almost momentary procedure must prove of great value in chest operations, when the more complicated apparatus for positive pressure-inhalation is not accessible.

The exact time of the operation was not noted, but the assistant who managed the colonic anæsthesia and then transferred the oxygen-tube to the nostril thinks that the time from the opening of the chest cavity until the last stitch fastening the diaphragm to the chest wall was tied was about twenty minutes.

The patient made an uncomplicated recovery. The microscopical diagnosis was large round-celled sarcoma. The rough ends of the fractured rib without any attempt at callus formation projected into a degeneration cavity in the interior of the tumor.

THE VALUE OF THE LEUCOCYTE AND DIFFERENTIAL COUNTS IN APPENDICITIS.*

BY GEORGE N. PEASE, M.D.,

OF NEW YORK.

Interne, Presbyterian Hospital.

A good many papers have appeared recently in regard to the value of the blood counts in appendicitis. So far we do not seem to have reached any definite conclusions as to what part of the blood count will enable us to judge most accurately of the pathological lesion present. To add to the data already published, and to see how the cases in this hospital compare with those already presented is the purpose of this paper.

The following series of 300 cases is taken from the services of Drs. McCosh and Eliot in this hospital. They are the last 300 cases operated on in this hospital. All the cases presented went to operation, and in each case a definite determination of the pathological lesion was possible. In almost all of the cases the blood counts were taken on the day of the operation, or the day before the operation, and no count dates back more than 24 hours previous to the operation.

The leucocyte counts in each case were made by the junior surgical interne in the hospital. The differential counts, on the other hand, were practically all made by the pathological interne, and were therefore counted by the same individual, which, in a series of cases like the present, should make a very reliable comparison of the different cases.

The following classification was adopted as best grouping and indicating the pathological lesions present:

1. Chronic appendicitis, including acute cases that have subsided and all interval cases.

2. Simple acute appendicitis,—cases presenting signs and symptoms of an acute process localized to the appendix itself, but without gangrene.

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3. Acute gangrenous appendicitis,—simply a further development of acute appendicitis.

4. Appendicitis with abscess formation,—cases with pus walled off about the appendix.

5. Appendicitis with local peritonitis limited to the region of the appendix, or spreading to neighboring regions such as the pelvis, but not yet general.

6. Appendicitis with general peritonitis.

TABLE 1 *

Variety	Number of cases	Average number of polynuclear leucocytes	Average number of leucocytes
Chronic	63	69 %	12,9:0
Simple acute	47	77 %	14,700
Gangrenous	28	85 %	19,400
With abscess	14	88 %	22,200
With local or spreading peritonitis.....	101	88 %	21,100
With general peritonitis	47	89 %	21,800

* This shows the number of cases of each variety of appendicitis in this series, and the average number of leucocytes and polynuclear cells present in each class of cases.

The above table shows, as we have already learned to expect, that the more severe the pathological lesion the higher is the leucocyte count, and the higher the percentage of polymorphonuclear cells in the differential count. An apparent exception to this is the leucocyte count in appendicitis with localized abscess, as compared with the count in cases with general peritonitis. In case of abscess, the average leucocyte count was a little higher than in general peritonitis, yet we classify general peritonitis as a much more severe lesion. The explanation of this probably lies in the fact that in many cases of general peritonitis the infection was so virulent that it completely overwhelmed the bodily resistance, and there was no reaction to the invasion. For example a good many of the cases of general peritonitis gave counts like the following:

Leucocytes, 5,000...................Polynuclears, 71 per cent.
Leucocytes, 8,100...................Polynuclears, 68 per cent.
Leucocytes, 7,500...................Polynuclears, 79 per cent.

Such count would, of course, greatly reduce the general average leucocyte and polymorphonuclear counts in the cases of general peritonitis.

TABLE 2*

Variety	Under 10,000	10,000 to 15,000	15,000 to 20,000	20,000 to 25,000	25,000 to 30,000	Over 30,000
Chronic	20	23	16	1	3	0
Simple acute	11	15	11	7	1	1
Gangrenous	2	6	10	6	3	1
With abscess	1	3	2	4	2	2
With local or spreading peritonitis .	5	16	29	29	9	13
With general peritonitis	4	11	10	8	3	11

* This shows the leucocyte counts in the individual cases of the six varieties of appendicitis mentioned above.

From the above table (Table 2) we see that it is impossible to decide upon the pathological lesion present from the leucocyte count alone. For example, we have 20 out of 63 cases of chronic appendicitis with leucocyte counts of over 15,000, and 21 out of 101 cases of localized or spreading peritonitis, and 15 out of 47 cases of general peritonitis with leucocyte counts under 15,000,—the latter two varieties, of course, being much more severe lesions, should, if the rule were absolute, have leucocyte counts far above 15,000. Practically all that can be said from the leucocyte counts alone is, that the majority of cases with leucocyte counts of over 15,000 are severe cases, and the majority of cases under 15,000 are mild cases, but there are many cases of both types that do not conform to this rule.

TABLE 3*

Variety	Under 75 per cent	75-80 per cent	80-85 per cent	85-90 per cent	90-95 per cent	Over 95 per cent	Total cases
Chronic...................	41	11	8	2	1	0	63
Acute	17	9	7	11	3	0	47
Gangrenous...............	5	0	6	11	5	1	28
Abscess...................	0	1	4	5	2	2	14
Local or spreading peritonitis	4	10	16	27	36	8	101
General peritonitis.........	4	4	4	19	13	3	47

* This shows the percentage of polynuclear cells in the individual cases of the different varieties of appendicitis.

On examining Table 3, we find that we can judge much more accurately of the pathological lesion present from the polynuclear count than from the leucocyte count. We see that practically two-thirds of all the more severe cases show a polynuclear count of over 85 per cent. By the more severe cases we mean the last four varieties in the table,—namely, (1) gangrenous appendicitis; (2) appendicitis with abscess; (3) appendicitis with localized or spreading peritonitis; and (4) appendicitis with general peritonitis. And we see that cases with a polynuclear count of over 90 per cent. are cases with peritonitis either localized, spreading, or general.

Cases with a polynuclear count below 80 per cent. we see are, as a rule, cases of chronic and simple appendicitis. A few cases with peritonitis come below 80 per cent., and these are the exceptional cases which we cannot classify by any method. Between 80 and 85 per cent. we find a number of cases of all varieties, and it only seems possible to designate cases in this column as " doubtful."

Our conclusions then from Table 3 would be:

1. A polynuclear count between 85 and 90 per cent. indicates the presence of a severe process.

2. Above 90 per cent. a dangerous condition probably complicated by peritonitis.

3. Below 80 per cent., safety for the time being.

4. Between 80 and 85 per cent., doubt.

5. These rules hold good for about four-fifths of this series of cases, there being many exceptions to each rule.

It is not the object of this paper to form any definite rule by which we can tell from the blood count when to operate and when not to operate in a given case of appendicitis. In fact, one point and probably the most important that this investigation has taught the writer is, that it is impossible to decide from the blood count alone what pathological condition we shall find, or even to determine whether the case is severe or not. There are many exceptions, and these we must learn to interpret by other means at our command.

One of the most recent methods and one which has aroused more investigation along the line of the value and

interpretation of the blood count in appendicitis, is that suggested by Dr. C. L. Gibson, of New York City (ANNALS OF SURGERY, April, 1906, " The Value of the Differential Leucocyte Counts in Acute Surgical Diseases "). He advanced the idea that the relation between the total leucocyte count and the percentage of polymorphonuclears gave the most valuable information. Ten thousand leucocytes with 75 per cent. of polymorphonuclears was taken as a base line representing the normal relation. For every rise of 1000 leucocytes there should be a corresponding rise of 1 per cent. of polymorphonuclears to maintain the normal relationship. Lines were drawn from the leucocyte count to the polynuclear count and designated as horizontal, rising, or falling lines according to the relationship between the leucocyte and the polynuclear count. In brief he says: " If the line connecting the levels of the leucocyte count and the polymorphonuclear count runs pretty near horizontal,—whether up or down,—with only 2 to 4 points difference, it indicates that a lesion whether severe or not is well borne, and therefore of good prognosis. If the difference of level between the two points is considerable, say 10 or more units, we are quite sure to have a pretty severe lesion."

The following table (Table 4) gives the result of applying Dr. Gibson's method to our series of cases.

TABLE 4 *

Variety	Rising line	Falling line	Horizontal line	Rising line five units or more	Total cases
Chronic........................	13	41	9	3	63
Simple acute	24	15	8	9	47
Gangrenous.....................	14	10	4	7	28
With abscess...................	9	5	0	5	14
Spreading or local peritonitis....	58	37	6	36	101
With general peritonitis.........	23	23	1	19	47

* To explain the totals: it must be remembered that the cases in column four, namely those showing a rising line of five units or more are included in column one, namely, those cases showing a rising line.

On examining Table 4, we see that the conclusion suggested by Dr. Gibson holds good in only about one half of the

cases of this series,—for example, of the 47 cases of general peritonitis, only 19, or less than half, showed a rising line of over five units, which is supposed to indicate a pretty severe lesion. Twenty-three of the cases of general peritonitis showed, on the other hand, a falling line, and this is supposed to indicate a mild process. Yet we must admit that no case of general peritonitis is considered a mild process. Again only 58 or a trifle over one-half of the 101 cases of localized or spreading peritonitis showed a rising line, and of these 58, only 30 showed a rising line of over five points. In other words, less than one-third of the cases of localized or spreading peritonitis would be considered severe cases according to Dr. Gibson's chart, and more than two-thirds of the cases would be considered cases of good prognosis. By far the greater part of these cases, however, proved on the operating table to be severe cases.

Dr. R. H. Fowler, of St. Luke's Hospital, in this city (*Surgery, Gynæcology, and Obstetrics,* September, 1908, " The Relation of Appendicitis to the Leucocyte Count ") reports 278 cases of appendicitis. After a thorough examination of these cases, he comes to the conclusion that the standard chart of Dr. Gibson offers the best method.

Dr. Noehren, of the German Hospital, this city (ANNALS OF SURGERY, February, 1908, " The Value of the Differential Leucocyte Count in Acute Appendicitis "), reports 69 cases. He concludes that the estimation of the percentage of polymorphonuclears alone is more reliable than any method that has so far been suggested—also, that a polymorphonuclear percentage of 90 per cent. or more indicates a severe process that calls for immediate operative interference; a percentage below 78 per cent. means a " safe," or mild process; a percentage between the two extremes speaks for the one condition or the other, according as it approaches the one extreme or the other.

With the first conclusion,—namely, that the percentage of polymorphonuclears is the most reliable method,—the conclusions reached in this paper agree; but with the second

conclusions,—namely, that operation is indicated, or not indicated, according as the percentage of polymorphonuclears is above 90 per cent. or below 78 per cent.,—we cannot agree. It may hold good in a certain number of cases, but the larger the series the more exceptions occur, and it seems best not to draw any hard or fast rules from our blood counts.

The writer wishes to thank Drs. McCosh and Eliot for permitting him to use their cases as material for this article.

TYPHOID FEVER WITH MULTIPLE PERFORATIONS, REPEATED OPERATIONS FOLLOWED BY ULTIMATE RECOVERY.

BY ALBERT J. ROBERTS, M.D.,

OF BRIDGEPORT, CONN.,

Assistant Surgeon to the Bridgeport Hospital.

D. N. P., male, 17 years old, was seen at his home on August 17, 1908. He had been ill two days. His pulse was 84 and temperature 102°. Although he lived in the country the surroundings of his home were very unsanitary. He was fairly developed but poorly nourished. Physical examination was negative.

Fever persisted and three days later he entered the Bridgeport Hospital. On entrance he had a negative Widal, but on August 26, the eleventh day of the disease, his spleen was easily palpable and Widal positive. The treatment was dietetic with sponge baths when the temperature was over 103°. There was no delirium and the course was uneventful until September 4, the twentieth day. At noon he felt as well as usual, and at 1.30 he had a natural bowel movement. At two o'clock he complained of dull pain in the lower abdomen, not localized. Dr. A. J. Mendillo, House Physician, reported this by telephone, and kept the patient under constant personal observation from that time. Immediately afterward he had a chill which lasted thirty minutes. The pain continued. The pulse was of good quality, but intermittent at times. Rate 78. He was tender three inches above the pubes a little to the right of the median line. There was no muscular rigidity and no distention. The abdomen was dull for three inches above the pubes and in the right flank. Liver dulness normal.

Patient was catheterized and four ounces of urine obtained. Area of dulness remained unchanged. He had the characteristic facies of acute peritonitis. At 5.40 o'clock, under ether, an incision was made through the right rectus below the umbilicus. On opening the peritoneum the small intestines were found injected and the mesenteric glands swollen and enlarged. A loop of ileum

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was delivered and followed down, each portion being returned to the abdomen as soon as examined. About fifteen inches from the ileocæcal valve a perforation, the size of an ordinary slate pencil, through a Peyer's patch was found, purse-stringed and Lemberted with fine silk. The rest of the small intestine was whole though the Peyer's patches were swollen and injected. A considerable amount of liquid contents had leaked into the peritoneal cavity. This was sponged dry and drained with rubber tubing through a counter opening in the right lower quadrant opposite the repaired gut. The original incision was closed in layers. The patient made a good recovery from ether.

For several days there was a copious serous discharge through the tube. As this lessened the tube was shortened daily and finally left out. His bowels moved regularly until September 14, ten days after the operation, when he showed signs of obstruction, temperature rose and relapse was feared.

The stitches were removed from the median incision on the following day and fæces allowed to discharge from a second perforation.

During the night of September 17, the patient began to vomit. His temperature at this time was 100.6° and pulse 82, both of which dropped the following morning. As he was now tender with some rigidity in the left lower quadrant, it was thought best to explore for pus. Under local cocaine an incision was made in the left lower quadrant and the diagnosis confirmed. Ether was then given, a counter opening made in the left flank, and rubber-tube drain inserted. Both wounds were left open. On the third day fæces were discharged through the drainage tube, and for several days, whenever an enema was given, most of it came out through the left flank wound.

The patient was now starving to death and regular solid diet was begun. This was supplemented by cod-liver oil inunctions daily. On September 28, a localized, dull, tender area appeared in the epigastrium midway between the umbilicus and the ensiform, accompanied by vomiting and pain. Another operation was considered, but fortunately the abscess drained spontaneously by the opening in the left lower quadrant. From then on the convalescence was uninterrupted.

ANGEIORRHAPHY.

SUTURE OF A DOUBLE STAB WOUND OF THE FEMORAL ARTERY AND VEIN.*

BY FRED. B. LUND, M.D.,

OF BOSTON, MASS.

MISS M., aged 14 years, was seen in consultation with Dr. E. Frederick Murphy on March 31, 1908. She was a healthy little girl, who, nine days before, had met with the following injury. She was getting the meat out of a cocoanut with the large blade of a jack-knife, when the knife slipped and penetrated the inner side of the left thigh just below the middle, making a small puncture and nearly burying the knife-blade. The wound at first bled rather freely, but the bleeding was stopped by her brother, who boiled a rag and stuffed it in the wound. She remained in bed after the injury, the thigh swelled somewhat, and seven days later there was a profuse hemorrhage from the wound. Dr. Murphy, who was called, found localized swelling around the wound; he applied an antiseptic dressing and on March 31 called me to see her.

I found a small wound just below the middle of the left thigh; a pulsating tumor could be seen and felt surrounding it. There was a distinct thrill on palpation, suggesting arterio-venous aneurism. The pulsation in the left dorsalis pedis was markedly less than in the right. The foot was warm and there was no swelling of the lower leg or foot.

Operation.—The next morning an incision was made over the tumor and as soon as the blood clot was expressed there was a smart gush of blood from the femoral artery. A tourniquet was applied. The femoral artery was dissected out from the upper end of Hunter's canal and found to present an oval opening one-quarter of an inch long in the front of the artery and a smaller slit in the back of the artery. There was a slit in the front of the femoral vein, which did not gape, however, on account of the weakness of the circular fibres. There was a small slit in the back of the vein (Fig. 1). The artery was lifted out of the way by

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* Read before the Boston Medical Library and the Surgical Section of the Suffolk District Medical Society on January 6, 1909.

a loop of gauze, and the openings in the vein sutured. ooo silk sutures were used and No. 14 sewing needle; mattress sutures were employed. They were passed through all the coats of the vessels, so as to evert the edges and bring intima to intima, leaving the least possible silk in contact with the blood current. Then the posterior slit in the artery was sewn, and, last of all, the oval opening in the front of the artery was sutured; five or

FIG. 1.
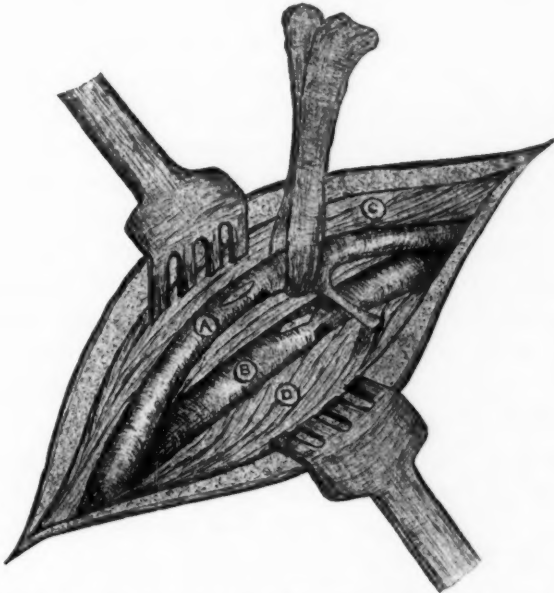
Stab wounds of femoral artery and vein in Hunter's canal (left leg). A, femoral artery drawn aside to expose femoral vein; B, femoral vein; C, sartorius muscle; D, adductor magnus muscle. The perforations on the outer aspect of both vein and artery are indicated in white. The perforations on the inner aspect are indicated in black. (From pen and ink drawing made by Dr. H. B. Smith, who attended at the operation.)

six sutures were required for this, and when the suture was completed, the opening being closed parallel to the axis of the vessel, the lumen was somewhat narrowed. On removing the tourniquet there was bleeding from two points, at either end of the anterior suture. Crile's clamps were applied to the artery above and below and these openings closed by two more sutures. The sartorius muscle was allowed to fall into place and the skin sutured with silk-worm gut. A rubber tissue drain was placed, and left in for twenty-four hours. A few moments after the operation there was slight pulsation in the dorsalis pedis. The

foot was swathed in absorbent cotton, and on April 16 the circulation in the foot was good. There was at no time any œdema of the foot or ankle, although at first it seemed as if the foot was a little blue. The case was shown May 2 and slight pulsation could be distinctly felt in the dorsalis pedis. In October, 1908, six months later, the little girl, who is now living out of town, was reported to be perfectly well.

The case is reported as one in which recent progress in the technic of arterial suture has undoubtedly saved the leg and foot of a patient. Ligation of either the artery or vein in Hunter's canal might not perhaps have resulted in gangrene of the foot; but ligation of them both, as would have been necessary had we not been prepared for arterial suture, would have undoubtedly had this result. The absence of subsequent phlebitis makes it evident that the lumen of the vein healed without thrombosis. The early return of pulsation indicates the same result in the case of the artery. A very similar case has been recently reported by Harry M. Sherman,[1] of San Francisco, with a similar result. His report is a good one and well worth reading.

To anyone but an antivivisectionist, it would seem as if the saving of the limbs of this girl and boy were worth the sacrifice of the temporary comfort or perhaps occasionally the life of a few dogs and cats. For we are compelled to acknowledge that our knowledge of the technic of blood-vessel suture is due to animal experimentation. The lateral and circular sutures of blood-vessels are among the simplest problems considered in the great field of arterial surgery, a field to which American surgeons have contributed much. The pioneer work of Dr. Matas will always remain a monument to him and to American surgery. Not only his operative skill, but his rare enthusiasm and thorough scholarship have combined to arouse the interest of surgeons all over the world in the work, and his operation has become the standard treatment for aneurism the world over.

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[1] California State Medical Journal, February, 1908.

Of the more complicated procedures in the fascinating field of arterial surgery—such as the transplantation of organs, the replacement of severed limbs, and the like—procedures which in the hands of such men as Carrel, Guthrie, and others have opened up almost limitless possibilities for the future, I have not the time to speak. With the exhaustive articles of Watts, Carrel, Sweet, and others, to which references are found at the end of this paper, we are all familiar.

It is my intention to take up only a few of the simpler and more practical points which interest us as surgeons, who may be called upon to treat accidental wounds or complete divisions of arteries and veins. Personally having had no opportunity to suture a completely divided artery, my previous experience has been limited to a suture of the axillary vein torn in the removal of a malignant growth (the rent being closed by three everting sutures, with excellent result), and lateral ligations applied to the injured internal jugular vein, which have also proved satisfactory. An operation for arteriovenous anastomosis of the femoral artery and vein, however, has given me an opportunity to compare an end-to-end suture in an accessible location, Scarpa's triangle, with the lateral suture in Hunter's canal, and I have no hesitation in saying that the former is the easier procedure. The depth of the dissection and the consequent difficulty in accurately placing the sutures in the under side of the vein readily account for this. I should in the future approach an end-to-end suture in an accessible location without great anxiety as to success.

The matter of temporary hæmostasis is important. When possible in wounds of the artery a tourniquet should be employed. In this case, intending to employ Crile's clamps in the belief that less collateral vessels would be cut off, I thought I could dissect above and below the opening sufficiently to apply them while the opening was plugged by the blood clot in and about the wound. As soon as the pressure of the skin and muscles was removed, however, the blood stream forced out the clot, and I had to put on the tourniquet in a hurry. After the suture had been completed, however, the clamps came in

handily for the application of the two extra sutures which were necessary owing to leakage between the sutures already placed in the artery. Here the re-application of the tourniquet would have taken too much time and disturbed the operative field too much, while the clamps were easily slipped on. Hæmostats or purely metallic clamps are out of the question on account of the danger of wounding the intima. Finger pressure, which has been recommended as the safest method, is not to be preferred because fingers take up too much space and get tired. A clamp with a screw and guarded by rubber, such as Crile's, and *carefully applied,* is the method of choice when the tourniquet cannot be used.

The point which stands out in a review of both the experimental and the clinical work which has made possible the suture of blood-vessels, is the importance of the avoidance of thrombosis. It may be of interest to know that the first successful closure of a wound in an artery was made in 1759 by Hallowell, an English surgeon, who closed a small wound in the brachial artery by placing a pin through the lips of the wound and passing a thread around it. In pre-antiseptic days, as was to be expected, little success was attained, nor were the earlier experimenters in the antiseptic era much more successful—Glück in 1881 and others till 1889—when Janissowski first proved by publishing the results of his experiments that arterial wounds could be sutured with preservation of the lumen of the vessel. Janissowski used interrupted sutures of fine silk and did not penetrate the intima, in order to avoid the presence of suture material in the interior of the repaired vessel, which might favor thrombosis. Later, Murphy, in 1897, published his experiments, recommending avoidance of the intima, as also did Silberberg. In 1899, Dörfler recommended the use of sutures penetrating the intima, and since then this has been the method of choice. Mattress sutures, either continuous or interrupted, may be used, and proved satisfactory in this case. The idea was to approximate firmly intima to intima, just as in intestinal suture endothelium is brought in contact with endothelium. This method is just

the reverse of the Connell intestinal suture—the arterial wall is everted, the intestinal wall inverted. In circular sutures, however, Carrel has shown that by taking three guide sutures and by them holding the vessel wall on the stretch, enough eversion may be attained by a simple running continuous suture of the intervening spaces. This is very quickly and neatly performed, and his experiments demonstrate that thrombosis does not occur.

Successful sutures of accidental wounds of arteries in man have been reported by Heidenhain, Israel, Sabanayeff, Orlow, Lindner, Garré, Seggel, Veau, Heinlein, Baum, Torrance, Sherman, and others. Successful circular sutures of divided arteries have been reported by Murphy, Djemil Pascha, Krause, Kummell, Payr, Brougham, and others. Murphy's invagination method of circular suture, while ingenious and in his hands successful, has not been generally accepted, since it has been found that by careful suture without invagination and consequent doubling of the thickness of the vessel wall, leakage can be prevented.

After the completion of a suture, pressure with a sponge for a short period will stop leakage from stitch holes, owing evidently to the formation of small thrombi. Leakage between the stitches which does not stop by pressure for a short time may be stopped by placing one or two additional sutures, as I found both in this case and in my case of arteriovenous anastomosis. Dr. Sherman points out that while the ideal suture would be both blood and water tight and not depend upon clotting, such ideal suture could not be attained, because if tied "water tightly," so to speak, the suture would cause necrosis of the tissues in its bight. Some clotting must evidently take place to close the little cracks, because the function must be taken up at once, without an enforced period of rest for healing.

Thrombus formation in animal experiments, according to Carrel, is usually due to sepsis, and he thinks a "stricter asepsis" is required for vascular operations than others. Sweet rightly objects to discussion of the degrees of asepsis.

Asepsis either is or is not, and partial asepsis does not exist. Asepsis, I think, rarely exists, and we have always known that in the presence of blood clot a higher degree of care is necessary to get primary union than in wounds in which the surfaces are not kept apart by that most excellent culture medium, a bit of thrombus. Inasmuch as in this operation we employ blood clot to calk our suture lines, it must always be there, and I am inclined to think Carrel is right in saying a special effort at asepsis should be made, in order to avoid the secondary clotting which would accompany infection, although a certain amount of primary thrombosis is essential to success.

As chief aids in preventing thrombosis, we must avoid as much as possible handling of the edges of the arterial wound with forceps, or even sponging any more than necessary. After one or two guide sutures are placed, we can often get along with the minimum use of forceps, lifting our vessel wall merely with the point of the needle. When, as happened in this case and in the arteriovenous anastomosis, little clots form in the lumen of the vessel, a medicine dropper filled with salt solution will wash them out quickly and neatly and thus avoid sponging and handling. This suggestion, which I got from Dr. Hubbard, I found of the greatest aid in both cases. The impregnation of the sutures with sterile vaseline and the smearing of the vessel with the same lubricant were employed in my arteriovenous anastomosis, but not in the case being reported. It is a great help, as the fine silk sutures when greased run through much more easily, with no tendency to stretch and tangle and knot. I think in addition to the fine, straight needles (which are easily procured, if married, from one's wife's work-basket)—fine enough for the femoral artery at least—we ought to have curved needles to sew up the under side of deeply situated veins. Beading needles are good, but very long, too long for use in a deep hole. For very small arteries the finest sewing silk may be untwisted, and one of the three strands of which it is made employed as a suture. Fine needles and the finest silk sutures are now kept threaded

at the City Hospital for use in accidents and operative cases where there is danger of wounding large arteries. It costs nothing but a little time and patience, of which, as is well known, hospital surgeons have always an unlimited supply on hand, to sew up injured vessels instead of tying them. If it does not succeed, they can be tied later. I believe that with ordinary care it will succeed, and that by the exercise of a little patience we can occasionally save a limb.

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PERFORATING WOUND OF THE KNEE-JOINT.

A CASE IN WHICH A PIECE OF STEEL WAS DRIVEN THROUGH THE KNEE-JOINT,
FRACTURING THE PATELLA AND CUTTING A CHIP OF BONE OUT OF THE
EXTERNAL CONDYLE; FUNCTIONAL RESULT PERFECT.

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O. H. B., white, aged 30, a machinist. On Feb. 14, 1908, while having a piece of six-inch steel shafting cut with a steam hammer, the piece of steel (½ x 2 inches) used for cutting was broken by the force of the hammer and a portion of it was driven through the left patella, tearing away the lower third and passing through the joint, cutting the posterior capsule of the joint near the upper margin of the articular surface of the external condyle of the femur and chipping out a fragment of the condyle about 2 cm. square.

He was seen first by Dr. E. C. Rosamond, who applied a sterile dressing without any attempt to probe or discover the extent of the injuries. I saw him with Dr. Rosamond a few hours later and had him removed to St. Vincent's Hospital for operation.

Under ether the limb was carefully cleansed and the wound irrigated and every precaution used to prevent infection. On opening the wound the above injuries were found with some clotted blood in the joint; this was removed with the gloved finger and irrigation.

The wound in the posterior capsule extended into the cartilage and in suturing it back a flap of cartilage had to be sutured; a small, curved, round needle with No. 2 chromic catgut was used and interrupted sutures were passed and tied so that the knots lay in the cavity in the condyle and presented a very small portion of gut on the joint surface; in places the suture was passed through the cartilage of the condyle and through the fragment of cartilage, bringing cartilage to cartilage; on the outer side the sutures were passed and tied in the same manner, having all of the knots external; the capsule beneath the patella was sutured and the fragments coapted and the patella ligament sutured over them, no attempt being made to suture the patella.

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A few strands of silk-worm gut were placed between the fragments of the patella to drain this space and a similar drain was placed in the cavity in the condyle, this being so placed as to drain the joint-cavity. The skin was closed with Mechel clips. The knee was wrapped in dry, sterile gauze and a posterior splint was snugly applied.

The dressing was changed the following day, there was no swelling or distention of the joint and only a small amount of synovial fluid on the dressing. The drains were removed on the third and the skin clips on the fourth day.

There was never the slightest sign of infection and the wound healed by primary union. There was no pain or discomfort and he remarked to me on the morning of the seventh day that he thought he could walk home if he were given a cane.

He was removed to his home on the fourteenth day, the wound was perfectly healed and the joint was normal in appearance and size and was free of tenderness and effusion; the patella was freely movable and slight manipulation of the joint did not demonstrate any restriction of motion.

A splint made with a hinge was put on at the end of three weeks, which allowed free motion up to a certain limit; this was removed at the end of five weeks and he was allowed to use the limb with only a firm bandage over the knee.

At the end of six weeks flexion was practically normal and he used the limb as well as before the accident.

After walking on it for several months he says he cannot tell that he has ever had an injury and every function and motion seems to be perfectly normal.

AN APPARATUS FOR THE INTRODUCTION OF SALINES INTO THE RECTUM.*

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THE plan of the apparatus here presented is the outgrowth of observations of the various methods of administration of the Murphy treatment. Inquiries have also been made into the method generally employed; and while all have for their common end the slow continuous introduction of salt solution into the rectum, there is a great divergence regarding many of the smaller details of technic.

The matter of regulating the relation between the intra-abdominal pressure and the hydrostatic pressure in the apparatus employed is by no means an easy one, when economy of time and the labor of nurses in the crowded wards of a hospital are to be considered. It is stated in the directions for treatment that the hydrostatic pressure be slightly in excess of the intra-abdominal pressure. If the reservoir employed for holding the salt solution be placed at such an elevation that the two pressures be alike, then there will be no flow. If now the reservoir be placed one inch higher the external pressure will be the greater and the flow will begin. Since only a comparatively few minutes are required for the salt solution to lower itself one inch, it follows that the two pressures will again be similar and the reservoir will again require elevation; in other words, almost constant attention is necessary if this nicety of adjustment of pressures be kept in mind.

Another observation which will be more fully explained on the basis of some physical experiments will show that as ordinarily given the salt solution enters the rectum after the

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* Demonstrated before the Philadelphia Academy of Surgery, December 7, 1908.

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first half-hour of administration at a temperature only slightly above that of the room.

With these things in mind it was my object to design an apparatus from which the flow could be controlled in a manner which would not interfere with the quick passage of flatus or the sudden expulsion of salt solution back through the tube and from which the fluid would enter the rectum at a temperature ranging from 100° to 115° F. Many forms of mechanism might be devised which would fulfil the above-mentioned conditions perfectly. Thermostatic regulators, "Thermos" reservoirs, etc., have been suggested, but in the administration of a treatment so widely used as that laid down by Murphy it is essential that the apparatus be as inexpensive as is consistent with fair work. To aim too strenuously toward perfection would make the cost prohibitory. It is not unusual in a large hospital to see as many as six patients at a time receiving continuous proctoclysis.

In order to get accurate data on the subject of heat radiation some laboratory experiments were done. To this end an improvised apparatus consisting of a reservoir surrounded by a chamber for holding a warming fluid was used. An attempt was made to keep the water in the reservoir at a fairly constant temperature and accurately to record the temperature of the fluid as it emerged from the end of the tube. The tube was four feet long and three-eighths of an inch in diameter. In the first experiment the fluid in the reservoir was kept at a temperature never above 130° F. nor below 124° F. and the rate of flow was regular, 350 cubic centimetres per hour. The temperature of the water at the end of the tube was obtained by having a thermometer bulb placed within its lumen, and readings were taken every ten minutes. Beginning with 129° F. they were as follows: 120° F., 92° F., 86° F., 84° F., 83° F., 82° F., 80° F., 79° F., 78° F., 80° F., and 78° F. From this it will be seen that at the end of two hours the temperature had dropped from 129° F. to 78° F.; in other words, it dropped to within two degrees of room temperature.

In a second experiment the same apparatus was used and temperatures were taken at the exit every ten minutes, the rate of flow being 400 cubic centimetres per hour. The reservoir stood at 129° F. and water was emerging at 110° F. At the end of fifty minutes the same readings were 100° F. and 86° F. respectively.

In a third experiment an irrigating bottle was filled with water at 185° F. and the whole was placed in a basin of constantly boiling water. A tube four feet long was used and the rate of flow was 400 cubic centimetres per hour. The first thermometric reading at the distal end of the tube was 176° F., and in twenty-five minutes it had dropped seventy-six degrees. The room temperature was 74° F.

A fourth experiment was conducted to meet as nearly as possible the directions given by Murphy in the June, 1908, number of *Surgery, Gynæcology, and Obstetrics*. In an irrigating bottle was placed water at 120° F. On either side hot water bottles at 180° F. were suspended. The distal end reading began at 100° F. and in one hour it had dropped to 81° F. The rate of flow was 500 cubic centimetres per hour and the reservoir remained at 120° F.

From these results it will be seen that not only must the water in the reservoir be kept at a higher temperature than is usually employed, if water at 100° F. to 110° F. be desired to enter the rectum, but some advantage must be taken of a means to prevent radiation from the tube. To meet this a tube was constructed which consisted of an inner tube wound with asbestos and over this a larger tube was placed enveloping completely the inner tube and its windings. The asbestos was used to prevent the two tubes from coming into contact and to entangle within its substance an air space. With the use of such a tube and the apparatus about to be explained the results were striking. Salt solution after running at a rate of only 300 cubic centimetres per hour was entering the rectum at 115° F. at the end of the first hour, 110° F. at the end of the second hour, and 92° F. at the end of the third hour. The solution was placed in the reservoir at 140° F. and

Fig. 1.
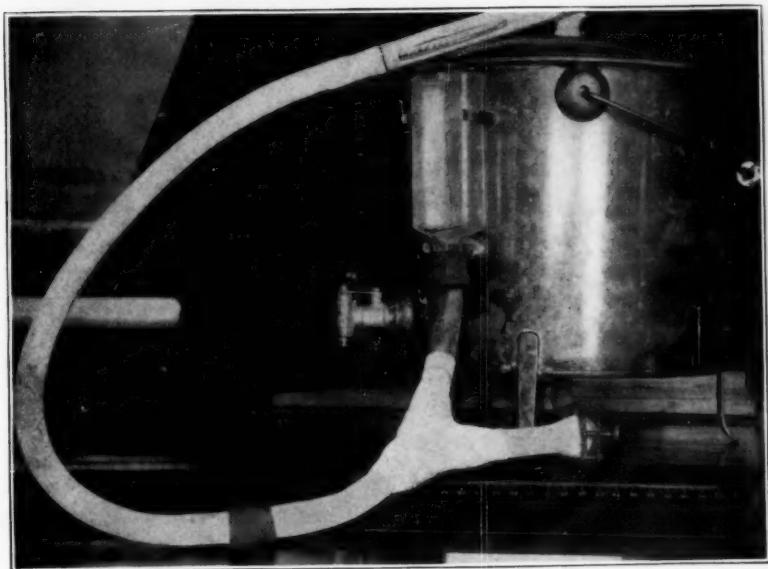
An apparatus for the introduction of salines into the rectum. Side view.

Fig. 2.
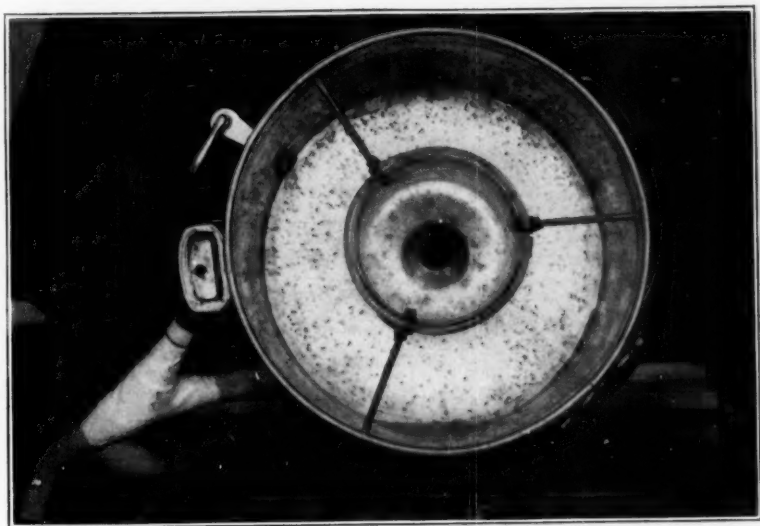
An apparatus for the introduction of salines into the rectum. Top view.

was surrounded by boiling water.   No change was made in
either of the waters until the end of the third hour.   If the
warming fluid had been changed the second hour the solu-
tion would have entered the rectum not lower than 105°
F.   The experiment just referred to was done on a patient
and continued from 2 P.M. until 2 A.M.   It was conducted by
pupil nurses of the Germantown Hospital Training School.
The rate of flow was controlled by a pinch-cock on the proxi-
mal end of the tube.   The salt solution was renewed only
twice and the warming fluid only three times.   The rate of
flow was as slow as 250 cubic centimetres per hour (a con-
dition most favorable to heat radiation) ; and only once did
the fluid at the thermometer at the distal end of the tube
register as low as 92° F.   Salt solution stained with fecal
matter was expelled back into the shunt reservoir from time
to time as the patient would cough, or strain from the pains
of an existing acute pyosalpinx.

A description of the apparatus as per accompanying photo-
graphs is as follows:

A copper bucket provided with legs on which to stand it,
a handle by which it can be hung, and a lid for prevention
of excessive heat radiation has in its bottom a central opening
and on its side a faucet.

Through the central opening passes the curved nozzle of
a graduated litre glass chamber.   This is supported and made
to press firmly against a rubber washer which surrounds the
hole in the bottom of the bucket by a frame and movable
fasteners.   In this manner a warming fluid is held within
the bucket and made to surround the reservoir which con-
tains the salt solution by a layer of water two and one-half
inches thick.   This can be quickly changed by running it off
through the faucet and pouring boiling water in the top.

The tube is constructed throughout as above explained;
that is, two tubes with a layer of asbestos between.   One foot
from the proximal end a Y-tube is interposed, and just proxi-
mal to the Y, and on the tube running from the reservoir, a
pinch-cock is placed in order that the flow may be controlled.

On the other proximal end of the Y is placed a shunt tube
which fastens to a receiving bottle provided with an opening
in either end, and attached to the side of the bucket. In this
manner the flow can be exactly regulated and at the same
time the salt solution or flatus can be easily expelled. This has
worked very successfully in actual experiment on patients.
There is allowed a to-and-fro movement of the fluid as easily
as if no pinch-cock were used. From the distal end of the Y
the tube continues to within seven inches of the rectum, at
which point an enclosed thermometer is interposed. This in
itself not only records the temperature, but it serves as a
guide to the rapidity of the flow. If the flow be too slow the
mercury falls and if it be too rapid the mercury rises. The
tube is three and one-half feet long and is so constructed that
a flow of from 400 to 500 cubic centimetres per hour will
enter the rectum at 105° F. to 115° F., provided salt solution
be placed in the reservoir at 140° F. and the warming fluid
be used at the boiling point. The tube should not be over
three and one-half feet long. This permits the placing of the
apparatus at or near the foot of the bed. The warming fluid
should be changed every two hours.

Directions for Use.—Fill the warming chamber with boil-
ing water. Fill the reservoir with salt solution at about 140°
F. Open the pinch-cock and allow the fluid to flow freely
until the tube is well warmed. Close the pinch-cock until
about two drops per second are flowing. To judge this hold
the rectal tube point upward not more than four inches below
the level of the water in the reservoir; otherwise one will be
deceived by the rapidity with which the tube will empty itself
distal to the stop-cock when the rectal nozzle is held too low.

Place the rectal tube—of the type directed by Murphy—
in the rectum and strap to the inner surface of the thigh.
Place the apparatus on an adjustable stand or tree, four to
ten inches above the level of the anus.

If salt solution be expelled into the bed or back into the
shunt bottle the apparatus may be lowered and the rate of
flow slightly decreased. If the patient persists in expelling

the solution discontinue the treatment for one hour and then proceed as before.

I wish to make known my indebtedness to Drs. A. D. Whiting and George Lord de Schweinitz for criticisms and for the use of clinical material in the wards of the Germantown Hospital, and to Mr. Keen, of Chas. Lentz & Co., for this trial apparatus constructed for my use.

THE SITTING POSTURE; ITS POSTOPERATIVE AND OTHER USES.

WITH A DESCRIPTION OF A BED FOR HOLDING A PATIENT IN THIS POSITION.

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SINCE the Fowler position has come into general use in the treatment of peritonitis, there have been described a number of devices for keeping a patient upright in bed. The essential principle of most of these has been elevation of the knees, whereby the trunk, when elevated, is prevented from slipping downward. The plan of putting a pillow under the knees is ineffectual, as the support is too yielding. Baldwin (*Journal American Medical Association,* vol. xlix, p. 1043) advises the use of an ordinary rocking chair. Allaben (*J.A.M.A.,* vol. xlix, p. 556) describes a back rest on the principle of a " double inclined plane." Gillian (*J.A.M.A.,* vol. li, p. 1133) advocates the use of a steamer chair. Finally, McGuire (*J.A.M.A.,* vol. l, p. 1019) gives the plan of elevating the head of the bed, and using an adjustable seat to keep the patient from slipping downward. All of these devices, under various circumstances, are no doubt very useful.

The bed described below has been used for about a year in the service of Prof. Halsted at the Johns Hopkins Hospital. While similar to the devices of Alleben and Gillian, it has several original features which, I hope, justify its description. Like all of the above inventions, it was planned for the treatment of peritonitis. But we have found it so easy to use and so comfortable to the patient, that we have employed it for a number of other conditions, for some of which the sitting posture has a value almost as great as for peritonitis.

The apparatus consists of an oblong frame of stout boards, to the upper surface of which are hinged three movable flaps. The frame is of the exact length and width of a stand-

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FIG. 1.
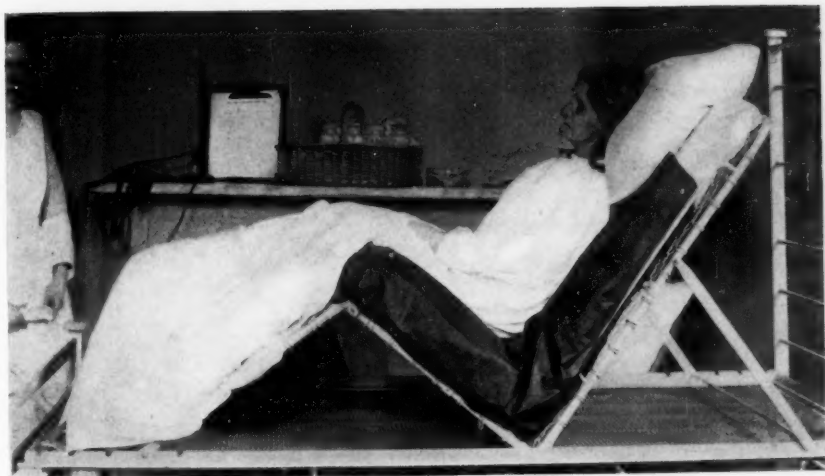
The iron bed in position on the springs of a ward bed. Draw sheet arranged as for continuous irrigation of bladder.

FIG. 2.
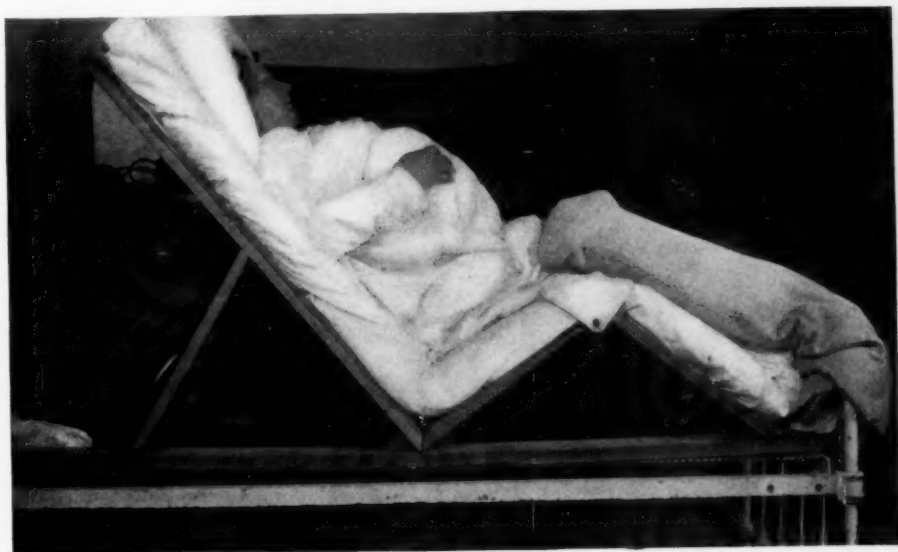
The wooden bed, showing ease with which an extremely heavy patient (the woman shown weighed 250 lbs.) can be kept sitting.

ard ward bed, on the springs of which it is intended to rest. The photographs (Fig. 1 and 2) show the relative length of these flaps, and the plan of elevating or lowering them. The flap which supports the trunk should be about 36 inches long; the smaller flaps should be 14 to 16 inches long.

To cover the bed we used at first a mattress hinged at the points of bending. But we found that an ordinary " Oster-moor " mattress, if strapped down, would bend as much as necessary. The straps should be sewed to the under surface of the mattress at a point about 6 inches from the edge, so as to allow the covers to be tucked in between mattress and strap. A rubber draw sheet under the patient's buttocks keeps the bedding dry.

Such a bed can be made by any carpenter at a very small expense, or it can be made of steel with woven wire backs for the frames. If desired, a hole can be cut through the mattress and the underlying flap of bed, so as to allow the placing of a bed pan without moving the patient. But this complicates the contrivance, necessitates a special mattress, and is of doubtful convenience.

It would, in fact, be perfectly easy to have every hospital bed equipped with movable frames of this kind, but with de-tachable canvas backs which could be buttoned to them when-ever it became necessary to have the patient sit up.

The advantages of the bed are, that it is simple; that it permits of the patient's lying flat or sitting at any angle of elevation desired; that it holds a patient in the sitting posture all the time, and without any effort on his part; that it permits of continuous irrigation of the bladder, rectum, or adjacent parts without wetting the bed or the patient; and finally, that it readily adapts itself to the comfort of a large class of patients who need to sit up more or less of the time.

Passing now to the therapeutic uses of the sitting posture, we may roughly divide the cases benefited thereby into two groups, the operative and the non-operative. In the former group it has, I think, four general uses: (1) to drain the peri-toneal cavity; (2) to lessen the danger of pulmonary compli-

cations; (3) to permit of certain continuous irrigations; and, (4) to promote the comfort and general well-being of the patient. In the non-operative group, there are numerous cases, of pulmonary and cardiac disease, of incontinence of urine or fæces, of paralysis, etc., who may be greatly benefited, or taken care of more easily, when kept sitting. Some of these conditions merit a brief consideration.

In peritonitis the Fowler position, to be at all effective, must be maintained all the time. Fowler advises that the patient, if his condition will permit, be propped upon the stretcher which transports him from the operating table to the bed. Buxton (*Journal Med. Res.*, March, 1907) has shown that there is an almost instantaneous rush of bacteria into the lymphatics of the diaphragm whenever infectious material comes in contact with it. If, therefore, the patient's body be allowed to slip down, even occasionally, from the elevated posture, the entire surface of the diaphragm will be periodically flooded with poisonous exudate. This is precisely what happens when one tries to maintain a patient in the Fowler position by means of a simple back-rest or by pillows. The constant lifting made necessary is exhausting alike to attendants and patient. Yates (*Surg., Gynæcol. and Obst.*, Nov. 1908) has shown the vital importance of absolute rest in this condition. Coffey (*J.A.M.A.*, March 19, 1907) by means of an ingenious cast of the peritoneal cavity has shown that it is necessary to elevate a patient's body as high as 45 to 50 degrees to insure drainage of the lumbar depressions of the abdomen.

For preventing postoperative pulmonary complications the sitting posture has a life-saving value scarcely less than it has for peritonitis. Especially is this true for fat patients who have undergone laparotomies for conditions of the upper abdomen, such as gall-stone disease, gastric troubles, or umbilical hernia. The respiratory distress of such patients is dreadful and the danger from pneumonia grave. The following case illustrates the benefit they derive from sitting upright.

C. C., negress, aged 40, weight 205 pounds. History and physical signs typical of gall-stone disease. Heart and lungs normal. General physical condition excellent.

Operation: Oct. 15, 1908. Cholecystostomy and drainage of common duct. Removal of gall-stones from gall-bladder, common and cystic ducts.

Patient withstood the operation well and was returned to the ward in good condition. In four hours her temperature was 103°, her pulse 130, and her respirations 52 to the minute. A bed of the kind described above not being available, an effort was made to prop her up on a back rest to relieve her respiratory distress. But she was so heavy that she sank deep down into the bed with only her head and neck elevated, so that her dyspnœa was even worse than when she was lying flat. Her abdomen remained soft and was not tender on palpation except in the immediate neighborhood of the wound. On Oct. 16 her condition continued grave; her temperature remained elevated, her pulse was thready, and her breathing shallow and gasping. She was constantly nauseated. Showers of fine moist râles could be heard over the bases of both lungs in the back. At 5.30 P.M. this day an adjustable bed was obtained and she was placed upon it, her trunk being elevated to an angle of about 40 degrees. There was an immediate and striking improvement in her condition. Her temperature sank in four hours to 100° and her breathing became perfectly easy. Her convalescence from this time was uninterrupted, but it was necessary to keep her sitting for two weeks, as she had difficulty in breathing whenever lying flat.

The clinic has had a series of cases like this, all similarly managed and with similar good results. With the postoperative treatment so conducted the operative risks are diminished.

It has long been the practice at this hospital whenever the wound-condition will permit, to have patients who are old, feeble, or who have pulmonary emphysema or bronchitis, to sit up as soon as they have recovered from the anæsthetic. Hypostatic congestion of the bases of the lungs is then not likely to occur, and the liability to pneumonia is lessened. Provided the patient is held upright without any effort on his part, there is no increased strain on an abdominal wound from this posture.

Closely related to the question of postoperative lung complications is that of abdominal distention following laparotomy. Here too the sitting posture is of advantage, and for two reasons: in the first place, because the diaphragm and abdominal muscles can compress the viscera more powerfully; and in the second place, because in this position the action of the heart is less impeded by the upward pressure of the distended intestines. The pulse of such patients almost always becomes slower and stronger when they are made to sit up. Perhaps some of the benefit of the Fowler position in peritonitis depends upon this latter factor.

We have found the bed very convenient in managing continuous irrigations of the bladder, in treating infections or burns of the thighs, genitalia or abdomen, and in caring for patients with incontinence of urine or fæces.

These patients are placed on a rubber draw-sheet (Fig. 1) extending from shoulders to knees. Shoulders and knees are then moderately elevated. Fluids then gravitate to the patient's buttocks and are there drained off at the side of the bed, without soiling mattress or covers. Excoriations of the abdomen from the discharges of fecal fistulæ can thus be admirably treated by a slow continuous irrigation.

This method is especially adapted to the postoperative care of cases of perineal or suprapubic prostatectomy. Many of these patients are feeble old men, liable both to urinary complications and to pneumonia. When the patient is kept lying flat, it is almost impossible to manage a continuous irrigation of the bladder without soaking bed and patient. If, however, the patient's buttocks are placed in a Kelly pad and his knees and shoulders elevated as above described he can be kept perfectly dry. In this posture he will generally drink water better, and he is certainly less predisposed to pneumonia than when lying.

Of the non-operative or purely medical cases, the bed has been found most useful for patients with advanced heart disease and orthopnœa. These cases need to be held upright constantly, otherwise they are tortured by sleeplessness, caused

by the attacks of dyspnœa which occur whenever they doze and slip down from the sitting position. Patients with pneumonia and asthma are similarly made more comfortable.

In the absence of circulatory depression it is hard to see why nearly every patient confined to bed for a long period would not be greatly benefited by sitting upright part of the time, provided, of course, that the sitting posture can be maintained without any muscular strain on his part. Fever alone is no contraindication. Patients when sitting can breathe better, can take food and liquids better, and are less liable to pulmonary trouble. As this position takes the pressure off the bony prominences of the back, they are in less danger of bed sores. And, finally, the vasomotor tone of the arteries is better preserved and the patients are not so liable to dizziness and swelling of the feet when they finally walk. In short, cause should be shown for keeping a patient lying, rather than for making him sit up.

I desire to thank Prof. Halsted and Dr. R. T. Miller for the privilege of making an extensive practical test of the bed described, and for encouragement in the preparation of this article.

A METHOD OF SPLINTING SKIN GRAFTS.

BY JOHN STAIGE DAVIS, M.D.,

OF BALTIMORE, MD.,

Assistant Surgeon in the Out-patient Department of Johns Hopkins Hospital.

EVERY surgeon has his own pet method of dressing skin grafts, and fairly good results are obtained when the grafted wound is dressed with gauze moistened with normal salt, or borax solution, 1 : 40; with overlapping strips of rubber protective; with dry gauze or powders; with silver foil; or when it is simply left exposed to the air without any dressing. However, there are many partial takes and failures for the reason that the grafts are not properly splinted after they are applied, and in consequence slip down with the dressings, or are floated off by blood or serum collecting beneath them. In order to overcome this difficulty it is necessary to reinforce the grafts with some material which has enough body to act as a splint, and at the same time is not too rigid to shape itself readily to any desired location. It is also very important that it should not adhere to the grafts and granulations, or cause too much pressure, and also that there be free escape of any secretions into the dressings.

After experimenting with various materials, I tried a coarse meshed net, such as is used for curtains. It is made of loosely woven bars of cotton thread, surrounding openings about 1 cm. in diameter. It is necessary to have the openings approximately this size as smaller ones often become clogged. This proved too flimsy, and also became adherent to the grafts. So in order to increase the body of the fabric, after washing out the sizing and drying, I soaked the material in a rubber solution made up of pure gutta-percha, 30 parts, and chloroform 150 parts, and found that after the chloroform had evaporated and the material was dry there was enough stiffness to give a very satisfactory splinting material. When prepared the net should be of a light grayish-brown color throughout.

Fig. 1.
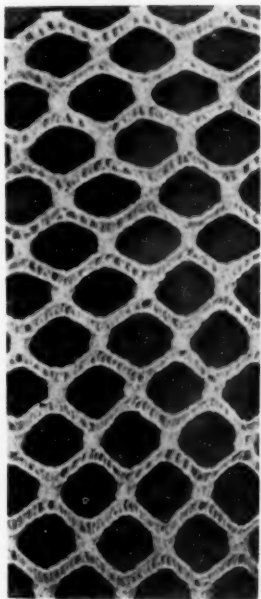
Shows the actual size of the
openings of the mesh.

Fig. 2.
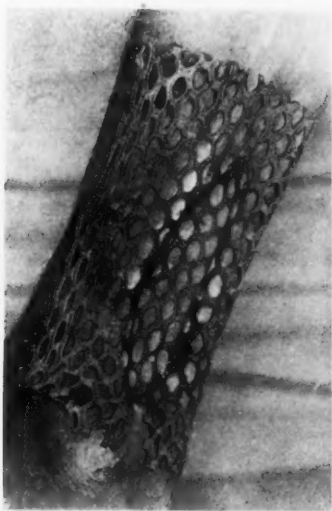
Shows the material splinting a whole-
thickness graft on ulcer following osteo-
myelitis of tibia. Note cuts to allow
accurate fitting. Photograph taken four
days after application of mesh.

FIG. 4.

FIG. 3
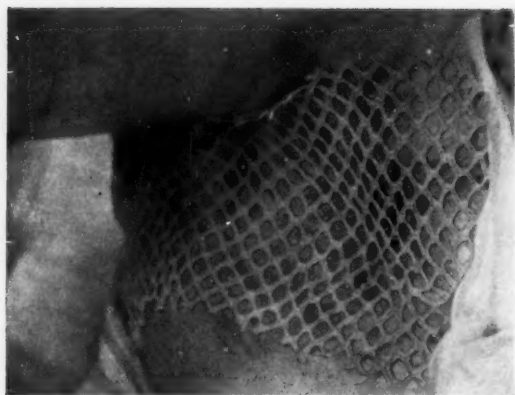
Shows the close fitting of the mesh over Thiersch graft on deep breast wound following excision of carcinoma on a very fat woman.
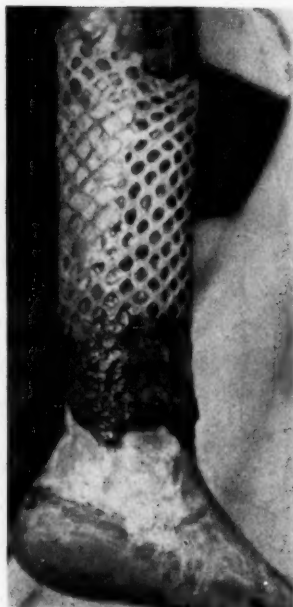
Shows the mesh over whole-thickness graft on burn. with the overlapping edges resting on granulation tissue. Photograph taken seven days after application.

The sterilization before application is as follows:

Cut in pieces as large as may be desired and separate them with one or two thicknesses of gauze.   Place in a sterile jar, and fill it with 1 : 1000 bichloride of mercury solution. Change this solution three times with twelve-hour intervals, and finally allow the mesh to remain permanently in 1 : 1000 bichloride solution.   It can be kept for a considerable time in this way (I have used it after keeping it nine months in the bichloride solution), although it is better to make up small quantities and often.   The dry permeated material will keep indefinitely.   No hot solutions must come in contact with the mesh during the sterilization or application.

Technic.—After the grafts are in place the mesh is taken out of the bichloride solution and thoroughly rinsed with salt solution, then dried with a sterile towel.   A piece is cut large enough to allow a margin around the grafted area of from 5 to 10 cm.   Then the material is applied and pressed snugly down on the grafted area and surrounding skin or granulations.   Should the conformation of the part or wound not permit the mesh to be evenly applied, a few cuts with scissors will allow an infolding and accurate fitting, which is necessary in order that the splinting may be successful.   The overlapping edges may be secured to the skin by strips of adhesive plaster when necessary.   After the net is in position the dressing selected is applied, and the whole secured by a bandage.

Where the overlapping material rests on granulation tissue, it will be found that it can be lifted up at any time without causing pain or bleeding, as the granulations do not adhere to or grow into the bars of the impregnated material.

With this mesh in place the grafts can be observed from time to time with little or no danger of displacing them.   The first dressing is usually made 36 to 72 hours after operation, and if the gauze next to the mesh has dried out, it must be thoroughly soaked with salt solution, and then carefully lifted with an instrument, while with a pledget of gauze the net is held down, as the dressing is raised from it, in order to guard against any displacement.   Then the wound is irrigated with

salt solution, and any secretions wiped away. The mesh is left in place from four to ten days, and then can be removed without difficulty.

Any type of dressing may be used over this material,—silver-foil, wet or dry gauze, etc., and I have found it particularly desirable in those cases where the grafted area was exposed to the air.

Conclusions.—The use of such a material permeated with rubber is advantageous in that it splints the grafts without too much pressure, and is easy to apply and secure in place. It does not adhere to the grafts or to granulations. It allows the free escape of any secretions which may form, and thus prevents maceration. Any sort of dressing may be placed over it. The progress of the healing may be observed at any time without danger of displacing the grafts. Should any blisters form and serum or blood collect beneath the grafts, it can be removed at once.

I have used this open-mesh material over Thiersch and " whole thickness " grafts, on nearly every part of the body, and have found its use a distinct advantage.

TRANSACTIONS

NEW YORK SURGICAL SOCIETY.

*Joint Meeting with the New York Pathological Society,
December 9, 1908.*

The President, Dr. Joseph A. Blake, in the Chair.

AN EXPERIMENTAL STUDY OF THE PATHOLOGY AND METABOLISM OF DELAYED CHLORO-FORM POISONING.

Drs. John Howland and A. N. Richards presented an elaborate review of this subject. The paper gave in detail the results of an experimental study of the pathology and metabolism of delayed chloroform poisoning and was illustrated by means of charts and microscopical projections. The pathological experiments were made upon numerous dogs, the metabolism experiments were carried out on three dogs. None of these latter animals died from the immediate effects of the anæsthetic.

The first dog was anæsthetized for three hours and a half, seemed always well thereafter and was killed on the morning of the fourth day following anæsthesia, when the general appearance of the animal and the metabolism showed her to be, as far as one could tell, perfectly normal.

The second and third dogs died as the result of delayed poisoning on the third and fourth days after the anæsthetic. In all three dogs, great pathological changes were found in the liver, the most important of which was necrosis.

Their metabolism showed an enormous increase in the excretion of total nitrogen, which was divided among the nitrogen-containing substances in an almost normal ratio except that creatinin was always diminished and the creatin, in the fatal cases, greatly increased.

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The total sulphur was also increased and proportionately higher than the nitrogen; this increase was due chiefly to an increase in the neutral sulphur.

The changes were the same in the dog apparently recovering as in the two cases of fatal poisoning, from which the authors conclude that the metabolic differences between ordinary prolonged anæsthesia and delayed poisoning are of degree only and not of kind. They found further no basis for the view that cases of delayed poisoning are due to acid intoxication.

They were able to produce in dogs necrosis of the liver after a single anæsthesia of an hour and intense fatty changes when chloroform was given for a much shorter period. They believe that every prolonged anæsthesia with chloroform produces intense liver changes in animals and that what is true of animals in this connection is undoubtedly true of human beings.

DR. GEORGE E. BREWER said he would limit himself to the clinical aspects of this very important pathological condition. The condition itself was a frightful one, and the death rate was high. It was not generally understood, for the reason that the cases were exceedingly rare. Still, in the literature covering the past decade a sufficient number of cases were described to enable us to formulate some definite rules regarding it. The cases could be classified under three distinct heads:

1. Those occurring generally in childhood in which the symptoms came on almost immediately after the use of the anæsthetic. In these cases, usually, the anæsthesia was of long duration, requiring the use of a good deal of chloroform, and they were apt to be associated with a profound degree of shock. The symptoms usually observed in these cases were prolonged vomiting, great prostration, coma and death.

2. This type, Dr. Brewer said, was also seen in children, and was distinctly an evidence of delayed chloroform poisoning. In a typical case of this character which he reported five years ago in the ANNALS OF SURGERY, the patient was a child, about twelve years old, who was operated on for appendicitis, with a limited peritonitis. Chloroform was administered, the anæsthesia lasting only about twenty minutes. The child recovered quickly from the effects of the anæsthetic, and passed a comparatively restless night. His temperature dropped to normal, and the following day he was quite com-

fortable. The abdominal distention disappeared, there was no evidence of marked tenderness about the abdomen, the patient's mind was clear, his temperature normal and he was considered convalescent. On the third day after the operation he suddenly awoke about midnight with a terrific scream; this was repeated a number of times—then he fell asleep again. About six hours later he again awoke, shrieking, and apparently terror-stricken and frightened, and then dropped off to sleep again. These paroxysms were repeated over and over again. Finally, his periods of sleep deepened into coma, and death occurred. During his waking periods there was restlessness and delirium of the wildest sort. There was no fever nor vomiting. An examination of the blood in this case showed that it was loaded with acetone and diacetic acid. Dr. Brewer said that Dr. Bevan, of Chicago, had reported a case almost identical with this.

3. The third type of cases of delayed chloroform poisoning was illustrated by the following instance, which had come under his observation: The patient was a man of 56 who had been operated on for an appendicitis of moderate severity. The operation presented no special difficulties, and was of short duration. Chloroform was selected as the anæsthetic, because of the condition of the man's kidneys. For forty-eight hours that patient did perfectly well; his temperature dropped nearly to normal and he had no untoward symptoms. Suddenly he became somnolent, and when aroused he would seem to be somewhat dazed. On the third day icterus developed and the following day he was the color of an orange. His somnolence progressed, coma developed and death followed. At the autopsy, the liver was found to be softened and yellow.

In reviewing the clinical histories of these cases, Dr. Brewer said, the following symptoms seemed to stand out prominently: Vomiting was quite generally present, although it had been reported absent. Restlessness was almost invariably noted in the beginning. Delirium was reported in those cases associated with acetonuria. Icterus was sometimes present; sometimes absent. Coma was always present before death. Fever was not usually a symptom, although in a few cases it had risen as high as 107° F. Cyanosis, air hunger and dyspnœa had been observed in a certain number of cases.

In those cases where the symptoms came on shortly after

the administration of the anæsthetic, and associated with evidences of considerable shock, certain unknown factors might be present, but in the late cases an exceedingly virulent type of intoxication must be looked for as the result of the chloroform itself. In addition to the cases reported, Dr. Brewer said he had seen several milder cases with somnolence and traces of acetone in the urine, in which the symptoms cleared up under liberal doses of bicarbonate of soda. The severe cases, he believed, almost invariably ended in death.

Dr. James Ewing said that when chloroform was first introduced, Magendie called attention to the possible dangers attending its use. It was a remarkable fact, the speaker said, that in spite of the commissions that had from time to time been appointed to investigate the subject of chloroform anæsthesia, little or no attention had been paid in their reports to this condition of delayed chloroform poisoning. This was especially so in England, where chloroform anæsthesia had been repeatedly investigated, and where Guthrie had reiterated his warnings in regard to the dangers attending this form of poisoning. The same condition held in France. In 1905, two French writers, in the *French Archives of Experimental Medicine,* described several cases of so-called toxic appendicitis with extensive alterations in the liver. The findings were practically identical with those observed in cases of delayed chloroform poisoning, although the authors did not mention the possibility of such an explanation; they simply referred to them as examples of a peculiar form of toxic appendicitis. They were probably dealing with cases of delayed choloroform poisoning. In their article, they quoted from half a dozen of the prominent French surgeons, each of whom had seen and reported similar cases. In one or two of their cases, the diagnosis of hystero-epilepsy had been made.

The worst offenders in this connection, Dr. Ewing said, were doubtless the obstetricians. In the practice of that branch of medicine, chloroform was very commonly used and a considerable number of the cases of so-called toxic pregnancy were really instances of delayed chloroform poisoning. The speaker said he could not entirely agree with the statement of Dr. Brewer in regard to the infrequency of this condition. On the contrary, he thought it was relatively common.

In discussing the pathological findings in these cases, Dr.

Ewing said that possibly some interesting additions to the facts might be learned by a study of the nervous system. Another question that arose was whether the findings in dogs were applicable to the human being. It was quite certain that the dog was a little more susceptible to these lesions than the rabbit, which was perhaps due to the fact that the latter animal could not be chloroformed as long as the dog. Rabbits were apt to die quickly under the influence of this anæsthetic. Whether man was more or less susceptible to the action of chloroform than the dog he did not know, but he was inclined to think that he was less so. The symptoms of delayed chloroform poisoning in the dog, however, as well as the pathological and gross findings, were apparently identical with those observed in the human being. Still, he thought it would be well to be cautious before interpreting these lesions as being due to the chloroform, as identical lesions occurred in man in certain diseases without the aid of chloroform.

In discussing the metabolic findings in these experimental studies reported by Drs. Howland and Richards, the speaker said he was surprised to find that there was so little change in the nitrogen partition and such a marked change in the sulphur output, and here again the objection arose to comparing metabolic studies in the dog with those in man. Spontaneous conditions in the human being in which we found these marked changes in the nitrogen excretion were not to be compared with the experimental condition produced in animals and covering a very short period. In the latter, the changes in the liver occurred very early, before the metabolic changes, while in the spontaneous condition it was quite the opposite.

Dr. Charles C. L. Wolf said that through the kindness of Dr. Howland, he had had the privilege of going over the results in the metabolism in delayed chloroform poisoning which he had presented, and while it might appear at first sight that the analytical results did not present changes commensurate with a fatal outcome, it seemed to him that they were particularly instructive in view of the direction which urine analysis had tended to take in the last few years. Instead of the routine analysis for urea by the hypobromide method, an accurate knowledge of the distribution of nitrogen was now desired, and this was given in the form of results similar to those of Dr. Howland. The speaker said that in the course of the work to which his entire attention

had been directed during the past four or five years, he had come across many conditions which bore out Dr. Howland's results in every detail.

Dr. E. Libman, the President of the New York Pathological Society, said he agreed with Dr. Ewing that this condition of delayed chloroform poisoning was not an infrequent one, particularly in its lighter form. While a discussion of this kind should not lead us to the other extreme, and blame everything on chloroform, we should nevertheless appreciate this possible occurrence of delayed poisoning from the effects of chloroform, particularly in those who suffered from some illness which predisposed them to acetonuria.

TRANSACTIONS

OF THE

PHILADELPHIA ACADEMY OF SURGERY.

Stated Meeting, December 7, 1908.

DR. GWILYM G. DAVIS in the Chair.

CARCINOMA OF PYLORUS; HOUR-GLASS STOMACH.

DR. WILLIAM L. RODMAN presented a woman, 43 years of age, who had given the history of chronic gastric trouble since she was fifteen. Six months ago her dyspeptic symptoms returned in a more pronounced way than ever before. She vomited irregularly, usually every two or three days. Her stomach contents did not show excess of hydrochloric acid or presence of lactic acid. A tumor near the pylorus was made out. The symptoms and signs clearly indicated an hour-glass stomach and a skiagram demonstrated such a condition. The pyloric compartment was very small and the cardiac compartment very large. There was considerable gastroptosis.

Three weeks ago this patient was operated on, and a large tumor was found near the pylorus. The pyloric end of the stomach was adherent to the liver and the pancreas. She bore the anæsthetic badly, and it was thought best to limit the surgical interference to a gastrojejunostomy, as the cardiac compartment was so large and the pyloric so small that they were practically dealing with a dilated stomach.

She has never vomited since the operation and her improvement has been steady and uninterrupted. She now claims that she never felt so well in her life. This, Dr. Rodman was satisfied, was a case of cancer ingrafted on the base of an old ulcer.

PERFORATING TYPHLITIS.

DR. RODMAN presented a girl, aged 17 years, who was brought to him from Cape May, N. J., during a most pronounced attack

of what was thought to be appendicitis. He saw her thirty-six hours after the onset of symptoms, which seemed to have followed eating peanut candy. Her pulse was 120, her temperature 103°, the rigidity of the right rectus muscle was most marked, and her pain was intense.

As soon as the abdomen was opened, thin pus and fæces were seen to be escaping from a hole in the cæcum about one inch from the base of the appendix. The latter was not free, but bound down in the mass of adhesions. The cæcum was very red, soft, and friable. He did not think it wise either to remove the appendix or to attempt to suture the opening in the cæcum. Therefore gauze drainage was made, one piece protecting the general cavity centrally, one passing downward to the pelvis, one upward towards the liver, one in the flank. The fifth piece led down to the opening in the cæcum. The superficial wound was not sutured. The Fowler position with Murphy's continuous irrigation was instituted at once after operation.

At the end of two weeks the pus and fecal discharge had ceased, and a second operation was done to remove the appendix. No perforation of the appendix was found, and it was easily removed in spite of the great amount of inflammation existing a fortnight previously. The wound was closed with tier sutures, and her recovery has been smooth and uneventful. This was evidently a case of typhlitis, rather than appendicitis. Dr. Rodman said that he had seen two or three other cases like it, each showing a marked perforation in the cæcum, in one of them as large as a quarter of a dollar.

SARCOMA OF THE BREAST.

Dr. Rodman presented a woman from whom a very large sarcoma of the breast was removed two weeks ago at the Presbyterian Hospital. It was a periductile sarcoma. Sarcoma of the breast is a rare neoplasm. He had operated upon but three cases in his life, two of these, strangely enough, in the last year.

S. W. Gross estimated that sarcomata comprised 8 per cent. of mammary neoplasms. Roger Williams examined 2300 cases and found that sarcomata comprised 3.8 per cent. Dr. Rodman had carefully examined the statistics covering 5000 cases of mammary neoplasms with the result that sarcomata comprise less than 3 per cent. of mammary growths.

Although a diagnosis of sarcoma was made in this case, a free axillary dissection was carried out just as in cancer of the breast. He thought that this should always be done, inasmuch as sarcoma not infrequently causes infection of the neighboring lymphatic glands.

PERFORATION OF FEMORAL ARTERY BY OSTEOPHYTE.

DR. RODMAN presented a man, aged 30, from North Carolina, who had suffered for fifteen years with disease of the right femur. There had been from time to time sinuses through which small pieces of dead bone were discharged. He came to the Presbyterian Hospital for treatment September 1. A few days afterwards another abscess formed; it was opened, nothing further being done. Within forty-eight hours afterwards he had hemorrhage from the popliteal. The wound was packed with iodoform gauze and the hemorrhage in this way controlled. Each time the packing was removed, hemorrhage recurred. The femoral artery was ligated under cocaine at the apex of Scarpa's triangle. This controlled the hemorrhage for a week, when another free bleeding occurred, presumably when the circulation was re-established. The femoral was again ligated under cocaine just below Poupart's ligament. The hemorrhage was controlled for another week. Recurring, it was deemed best to amputate the thigh. He almost perished from shock. After the limb was removed, two spiculæ were found, sharp as the prongs of a fork, sticking backwards in the popliteal space, which had cut both artery and vein across. The specimen presented shows clearly enough the injury to both vessels.

It is hard to understand why gangrene did not ensue. The femur was two and a half or three times its normal size, the result of chronic osteoplastic osteitis. The amputation was made in the upper third of the thigh. He has gained twenty pounds in weight and all of his septic symptoms disappeared promptly after operation.

OMENTAL CYST.

DR. RODMAN presented a girl, aged 17, who was operated upon three weeks ago in the Medico-Chirurgical Hospital for an enormous cyst of the abdomen weighing sixty pounds. It had been variously diagnosticated by different surgeons as a pancreatic

cyst, an ovarian cyst, and as free fluid in the peritoneal cavity. She had been tapped three times, the fluid being clear and limpid as spring water. The tumor was beneath the parietal peritoneum, covered over by an additional layer of peritoneum, but superior to the great omentum. It had no pedicle at all. But a single vessel was tied, and that a small one. It shelled out as a walnut from its covering. The cyst was unilocular. Seemingly, it was a cyst of the omentum. No abdominal viscus was seen during the operation.

Her recovery was rapid and complete.

SARCOMA OF BREAST.

DR. JOHN SPEESE presented, for Dr. Jopson, a specimen of sarcoma of the breast, occurring in a colored woman fifty years of age, in which the macroscopic appearance suggested that of the cystosarcomata described by many German pathologists. Several cysts were present, the contents having undergone coagulation. Microscopic examination revealed a malignant growth of connective-tissue origin, consisting of great numbers of spindle cells. The glandular portions of the breast also showed evidences of hyperplasia, the epithelial cells being heaped up in the ducts and tubules, but not infiltrating the surrounding tissues.

HYPERNEPHROMA OF THE KIDNEY.

DR. JOHN H. GIBBON presented a man 54 years of age, who was received into the medical wards of the Pennsylvania Hospital on September 18, 1908, under the care of Dr. Stengel. Three weeks before admission he began to have pain in the upper right quadrant of the abdomen, which he stated was increased by taking food. At this time a distinct tumor was easily palpated below the costal border, and apparently was connected with the liver. There was nothing in the repeated urinalyses to suggest any inflammatory condition of the kidney. The patient's hæmoglobin was 55 per cent.; color index, 0.674; leucocytes, 4100; and his red cells 4,360,000. An X-ray plate was made but showed nothing. It was thought that the tumor was probably connected with the kidney. Ureteral catheterization was done by Dr. Stewart, and proved of great diagnostic value. The catheters were inserted in the ureters and the glasses attached at 11.45 o'clock; at 12.05 a four-grain capsule of methylene blue was given. At

2 P.M. the methylene blue appeared in the urine from the left ureter, and in the urine from the right kidney not until more than an hour later. The catheters were removed at 3.07, during which time there were excreted from the left kidney 97 c.c. of urine, and from the right 9 c.c. There was no pus in the urine and the patient had no leucocytosis.

An incision was made through the sheath of the right rectus and the peritoneum overlying the tumor was divided. In separating the tumor from the surrounding tissues a projecting mass from the posterior surface was found, which was probably an extension of the disease beyond the capsule, so that its complete removal was made more difficult. The operator finally, however, was able to get completely around this mass, although it was densely adherent to the spine. The ureter and vessels of the pelvis were ligated separately and the tumor removed. There was considerable oozing from the large cavity left after removal of the tumor, and a gauze drain was inserted. No sutures were placed in the posterior peritoneum in this case. The anterior wound was closed excepting at the point of drainage. The patient stood his operation well and made a good recovery. He had an X-ray burn which has now healed. For a time he had œdema and tenderness in the posterior abdominal wall. This entirely disappeared, however, and he seems now in a fair way to make a complete recovery from his operation, although recurrence is to be expected.

The pathological diagnosis of the growth in this case was hypernephroma of the kidney.

SARCOMA OF THE KIDNEY.

Dr. John H. Gibbon presented a boy, four years of age, who was operated upon a year ago at the Jefferson Hospital. The case occurred in the practice of Dr. George T. Tracy, of Beverly, New Jersey, and was seen by Dr. Gibbon in consultation with Dr. E. E. Graham. The boy at that time had an enormous tumor involving his right kidney. This tumor was first noticed a few weeks before admission. It was large enough to be easily seen at a considerable distance. Because of the size of the growth the prognosis was particularly grave, nevertheless the patient's parents were anxious that operation should be done.

The child was given chloride of ethyl-ether anæsthesia, and the

peritoneal cavity opened over the tumor. The posterior peritoneum over the tumor was then divided and the entire mass removed. There seemed to be no extension beyond a well-defined capsule. The tumor was delivered through the abdominal wound before the pedicle was ligated. After ligating the blood-vessels of the pedicle an attachment to the lower portion of the tumor came into view, which turned out to be composed of kidney substance, and extended across the spinal column to the opposite side, where it was attached to the other kidney. It was about the size of a little finger. The left kidney seemed normal in shape, and had a distinct pelvis. The connecting link passed to its lower pole. There was no evidence of any disease in this isthmus, which was then ligated and divided. The posterior peritoneum was closed and the abdominal wall closed in layers without drainage. After removal the tumor was split and the growth found to be one which completely surrounded the kidney but only partially involved this organ. It had apparently started from the suprarenal. The specimen is nearly as large as the child's head. The ureter and calices were normal in size. One calix extended into the isthmus which had been divided.

Pathological diagnosis of this growth was spindle-celled sarcoma.

The boy made a prompt and very satisfactory convalescence. About a month after his operation he passed some blood in his bowel movements. Since that time, however, he has steadily improved in spite of an attack of measles, of chicken-pox, and one or two attacks of croup. He has gained ten or twelve pounds in weight and is passing a satisfactory amount of normal urine. There is no evidence of any hernia at the site of the incision, nor is there any evidence of any recurrence of the trouble. The boy has a good color and seems perfectly well. These large sarcomata involving the kidney are peculiarly fatal, and recurrence after removal usually takes place promptly.

DR. HENRY R. WHARTON thought it rather remarkable to have a child doing well a full year after an operation for sarcoma of the kidney. He recalled two similar cases in which recurrence took place within six months, proving fatal in a short time, and he had never had a case in which recurrence has not taken place sooner or later.

THE RESULT FIVE YEARS AFTER EXCISION OF THE HU-MERAL HEAD FOR CONGENITAL SUBACROMIAL DIS-LOCATION OF THE HUMERUS.

DR. JOHN B. ROBERTS presented a boy, eight years of age, who was operated on for congenital dislocation of the left humerus at the Methodist Hospital five years ago.[1] The head of the humerus was excised at that time. Examination shows the left humerus to be very much shorter than the right, but the motions of the arm as a whole are much more free than at the time he was seen previous to operation.

Measurements from the tip of the acromion to the external condyle are difficult to make with accuracy because of the boy's perpetual movements, but the right arm is apparently 9¾ in. in length from the points mentioned; the left, 7 in. The upper end of the humerus seems to move quite freely under passive motion made by the surgeon and there is marked grating.

When the child places his left hand on his right shoulder or on his head the scapula, however, moves with the humerus. He can put his left hand on the opposite shoulder, on the top of the head, and on the back of his neck, and move it from the occipital region to the vertex without difficulty and without using the right hand to aid the left arm by lifting the elbow as he did originally. He cannot raise the left arm outward much above the horizontal line, though he can sling it higher than that.

Both arms hang at the side with the thumbs out and with the humerus quite near the chest. External rotation of the hand carries the thumb of the left hand nearly as far outward as on the right side. There is, however, no rotation made at the shoulder joint as on the normal side. The entire external rotation is in the forearm. The humerus can be rotated outward passively, but the little boy does not do it himself. It is a little difficult to get a true estimate of the ability to make the voluntary motions desired because of the boy's restlessness and inattention. The grasp of both hands is apparently the same, and the power of flexing and extending the elbow-joint seems alike on both sides. The biceps on the left side shows the abnormal swelling due to the loss of the proper attachment of one head, but the flexion of the elbow seems to be about as strong as on the other side. Supination of the hand is a little restricted.

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[1] American Journal of the Medical Sciences, Dec., 1905.

The boy can bring the upper arm quite close to his ribs and as stated before can place the palm upon the neck and head with ease. He can pull his left ear and right ear, and can place the left hand readily behind him and touch the lumbar region with the back of the hand.

There is some atrophy of the muscles in the supraspinous and infraspinous fossæ of the scapula, as there is of the muscles of the forearm and upper arm. When he attempts to elevate the left arm, as in using the deltoid, he has to give it a swing, and the scapula moves with the humerus. He can then bring the arm up quite well, though he cannot retain it above the horizontal line.

There is little, if any, lateral spinal curvature.

There is shortening of the left clavicle, which from the sternum to the scapula measures 5½ in., whereas the left is 6 in. long. The ulna on the abnormal side appears to be the same length as that on the normal side, measuring 8¼ in. from the insertion of the triceps to the head of the ulna at the wrist.

DR. GWILYM G. DAVIS said that the bulk of these luxations seem to be congenital, very likely produced at the time of birth, traumatic ones acquired after birth being comparatively rare. He thought the congenital cases are more common than is usually supposed. It is usually caused by the internal rotation of the arm, and it would be interesting to know whether in this case there was a history of difficulty in birth.

DR. JOHN B. ROBERTS said that these dislocations are supposed by many to be results of parturition. There have, however, been reported a few cases of bilateral dislocation, and several cases of the occurrence of this dislocation more than once in the same family. It seems unlikely that a child would get double sub-acromial dislocation of the humerus in parturition, or that two or three children in one family would have the same accident. He could not but believe that they are as much congenital as dislocations of the hip. Some believe them to be due to paralytic conditions of the arm produced at birth. They are interesting and deserve more study than is given them, for they are rare. Dr. Roberts believed them to be true congenital dislocations. He had seen but two such cases, the one operated upon and another in which the patient's friends objected to operation.
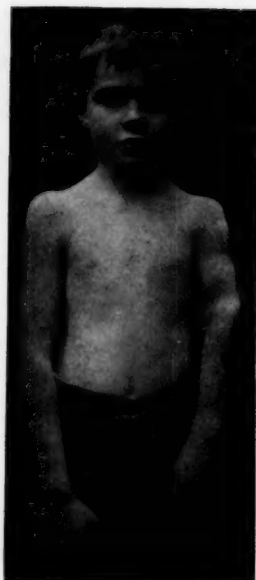
Fig. 1.
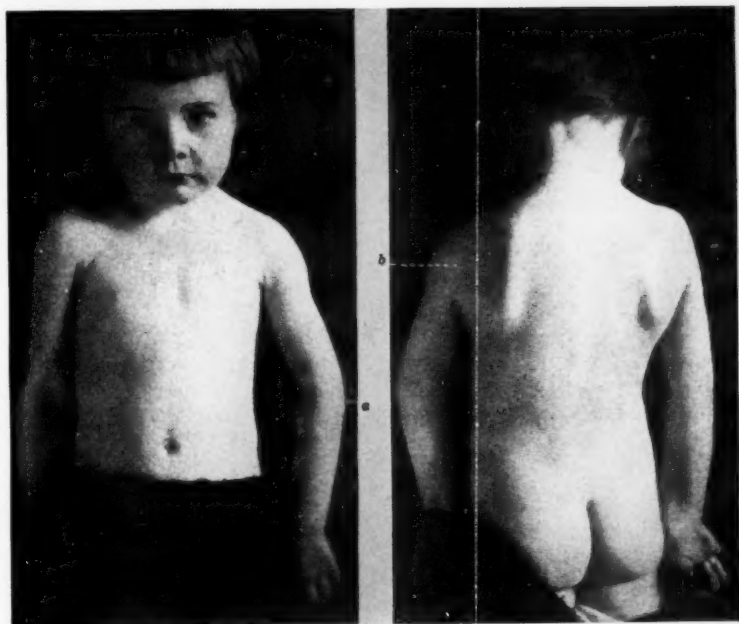
Congenital subacromial dislocation of the left humerus. Boy, aged three years. Observe abduction and inward rotation of humerus. Before operation. *a*, olecranon points directly outward and external condyle forward. *b*, head of humerus.

Fig. 2.   Fig. 3

Excision of head of left humerus five years ago for congenital subacromial dislocation of humerus. Boy is now (Dec. 7, 1908) eight years old. Observe shortening of arm.

Excision of head of humerus five years ago for congenital subacromial dislocation of humerus. Boy is now (Dec 7, 1908) eight years old. Observe shortening of arm and the ease with which left elbow is carried near chest.

FIG. 4.

Hand on head rest is up as high as he can get it with-
out twisting body. Before operation five years ago he
could not raise left arm without aiding it with other hand.

Fig. 5.

Congenital subacromial dislocation of the left humerus before operation. Observe abduction rotation of humerus, shown by the elbow being held away from the thorax, with olecranon pointing outward.

FIG. 6.

Congenital subacromial dislocation of the left humerus, after excision of the head. Skiagraph taken about three months after excision of the head of the humerus. Observe the absence of abnormal rotation of the humerus, which is seen in the skiagraph taken before operation. The abduction of the humerus seen here is voluntary.

FRACTURE OF THE PELVIS WITH RUPTURE OF THE ABDOMINAL WALL.

DR. ASTLEY P. C. ASHHURST reported the case of a man, 26 years of age, who was admitted to the Episcopal Hospital, in the service of Dr. Davis, Jan. 1, 1908. He had been caught between two trains, his pelvis having been crushed laterally. There was no marked shock on admission. There was a comminuted fracture of the crest of the right ilium, from the region of the anterior superior spine backwards for about four inches, the larger fragment being about two inches in breadth and four inches long. There were no particular symptoms of intra-abdominal injury. Urine drawn by the catheter was clear. There were numerous abrasions and contusions, and there were several immense hæmatomata in the subcutaneous tissues of right flank, external iliac fossa, right buttock, upper part of thigh, sacrum, and lumbar spine. Below the right costal border a rent in the abdominal muscles was clearly palpable through the skin, which was nowhere perforated. As the hæmatomata steadily increased in size, it was determined to attempt the repair of the abdominal wall and the replacement of the fractured bones, and to exclude intra-abdominal injury by exploration.

Accordingly, at midnight, four hours after the injury, a transverse incision was made at the level of the umbilicus, over the most evident seat of injury. This incision extended from the right semilunar line outward for three or four inches. Over a pint of fluid and clotted blood was evacuated, and a large and ragged rent was found in the oblique and transversalis muscles of the abdominal wall, with the lower intercostal nerves, apparently intact, spanning the gap like fine silken threads; a coil of gut, covered only by the parietal peritoneum, bulged into the wounded area. The peritoneum was opened, and two fingers inserted for exploration at once caught hold of a long, thick, and rigid appendix, which was drawn out for inspection: The appendix was not inflamed, but contained a firm concretion near its tip, and its lumen was distended with fecal matter of the consistence of putty, thus accounting for its rigidity. The appendix was removed. A gauze sponge, passed into the pelvis, found no evidence of blood or fæces, so the peritoneum was closed. The rupture in the transverse muscles was repaired in layers, by buried sutures of chromic gut, and the skin incision was then enlarged

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at right angles to the first, downwards over the site of the fracture of the pelvis. Here the oblique muscles were found completely detached from the crest of the ilium, and the iliacus also was torn loose from the internal iliac fossa for two inches towards the sacro-iliac joint. The whole crest of the ilium was broken loose, and was drawn downwards and outwards on to the buttock, by those few fibres of the glutei muscles which had not themselves

FIG. 7.
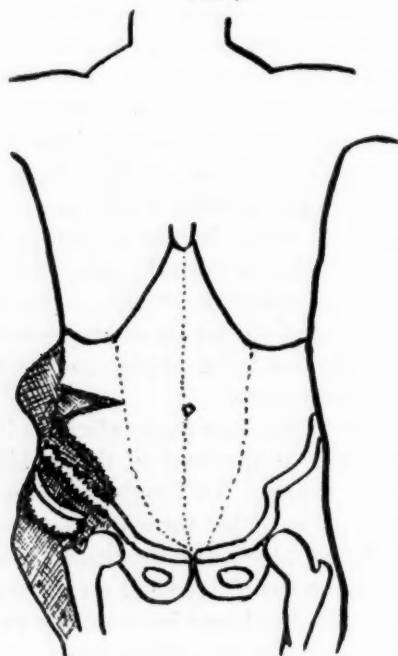
Fracture of crest of right ilium, with rupture of the abdominal wall. (Shaded area represents hæmatomata.)

been ruptured. Much liquid and clotted blood was evacuated from this region also. The displaced fragments were pulled back to their normal relations, and were held there by passing inter-rupted mattress sutures of heavy chromic catgut, by means of a Reverdin needle, from the gluteal muscles below, through the remains of periosteum and muscular tissue on the crest of the ilium, and up through the oblique muscles of the abdominal wall, and then back again to the starting point in reverse order, so that when these mattress sutures were pulled tight and tied, they drew the gluteal muscles up from below, and the oblique muscles

Fig. 8.
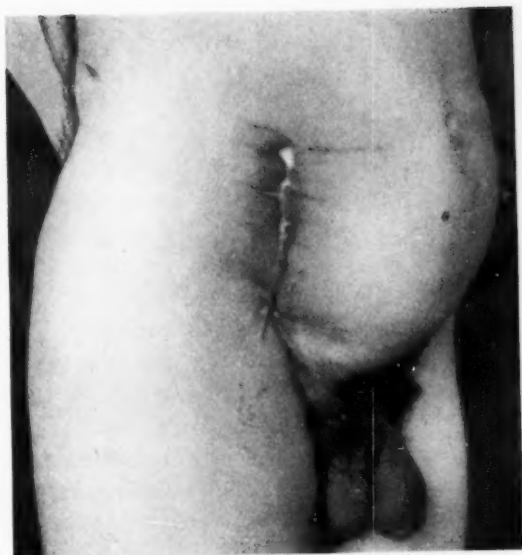
Fracture of pelvis with rupture of abdominal wall. Counter-incision in loin to drain hæmatoma.

down from above, and thus fixed the iliac crest with reasonable security between the two. Drainage from the fractured area was provided for by a rubber tube and two pieces of gauze. The superficial fascia was sutured with buried sutures, and the skin with silk-worm gut. Finally, an incision was made over the hæmatoma in the kidney region, and this was drained by a rubber tube. No attempt was made to evacuate all the blood in the various hæmatomata, as to do so would have required incisions all down the thigh as well as over the sacrum. Yet the sound of the liquid blood splashing about in these cavities was sufficiently alarming as the patient was lifted off the operating table, the admission of air to the cavities making the sounds very audible even across the room. The duration of the operation was fifty minutes.

The patient did well, and it was noted the next day that there was no pain except on motion. By the third day all the other hæmatomata had drained out through the one opening. Three weeks after the operation (Jan. 21, 1908) there was high fever, and considerable constitutional disturbance, due to the damming up of a hæmatoma in the loin. This was opened through the original incision in the loin, and the temperature reached normal the next day. At this time the abdominal incisions were practically healed, only a small sinus remaining. The bone seemed firmly fixed in place.

The patient sat up in a chair on February 17, and was discharged about the first of March, walking with a moderate limp. He has been an out-patient since that time, and now walks without any limp, and has no disability of any kind. A small sinus, due to slight caries at the site of fracture, persists, but it requires to be dressed only once in ten days, there being almost no discharge. The abdominal wounds are firm, and there is not the slightest tendency to hernia or bulging of that portion of the abdomen. He has been doing light work all summer, but has not yet returned to his work of railroad brakeman.

EXTRAPERITONEAL RUPTURE OF THE BLADDER, WITHOUT FRACTURE OF THE PELVIS—TWO CASES.

Dr. Ashhurst related the histories of the following two cases:

Case I.—Archibald McD., aged 43 years, was admitted to the service of Dr. Davis, Jan. 30, 1908. While at work, in a

stooping posture, he had been struck across the right loin by a falling telegraph pole, and was crushed to the earth. On admission he was seen by Dr. Davis; at this time there was moderate shock (temperature, 97.2° F.; pulse, 88; respiration, 32), and it was ascertained that two ribs on the right were fractured; there were no other symptoms. About five hours later, signs of internal hemorrhage began to be evident, the patient having recovered from his shock. There was great tenderness over the right kidney region, and some abdominal rigidity. Nearly pure blood, with no clots, was drawn by catheter. Small amounts of boric acid solution injected by the resident into the bladder were all recovered. (Later it was learned that only two ounces at a time had been injected.) Examination at this time showed evidences of deep hæmatoma in the right lumbar region, with swelling, dulness, and marked tenderness. Dr. Ashhurst thought it probable that there was an extraperitoneal rupture of the right kidney.

Operation at 9.45 P.M., about eight hours after the injury. An oblique right lumbar incision was made, retroperitoneal; a moderate-sized hæmatoma was evacuated from among the lumbar muscles, but the kidney when brought into the wound was found to be uninjured. The lumbar wound was closed without drainage. The patient was turned over on his back, and a hypogastric incision through the right rectus muscle was made. Free extraperitoneal hemorrhage was found in the space of Retzius, but it was decided to explore the other kidney and the ureters as a matter of precaution. The peritoneum was therefore opened: the intestines were normal, and there was no free fluid; the left kidney was found normal on palpation, and no evidence of intraperitoneal injury could be discovered. There was a large hæmatoma in the extraperitoneal tissues of the *left* pelvis and the *left* iliac region. The median hypogastric incision was closed without drainage; and a third incision was made through the left rectus muscle, close to the pubic bone, opening the extraperitoneal hæmatoma, which seemed to have its origin around the neck of the bladder and the prostate, though no definite rupture of the bladder could be found. A catheter passed by the urethra showed the bladder to be empty, and no rupture could be brought to view. The oozing areas around the neck of the bladder were packed with iodoform gauze, and the bladder was opened at its dome, was stitched to the abdominal wall, and drained by a large rubber tube. The operation lasted one hour. During most of it the patient

was pulseless, and only by the use of saline solution intravenously did he leave the operating room alive.

The next morning the patient appeared to have some chance of recovery; four ounces of nearly clear urine had drained from the bladder, and there was very little hemorrhage from the pelvic tissues. Up to the time of death, twenty-nine hours after operation, eleven more ounces of urine drained from the bladder, or fifteen ounces in all since the operation. As there was no further bleeding, and no evidences of peritonitis, death was attributed to shock.

CASE II.—Fred S., aged 20 years, was admitted to the service of Dr. Frazier, Nov. 23, 1908. While driving a wagon it rolled down an embankment, killing one of the horses, and crushing the patient. On admission there was considerable shock (temperature, 97° F.); there was inability to pass urine, and pure blood was drawn by the catheter. It was impossible to recover any fluid which was injected. There was great abdominal pain and rigidity, with dulness in the flanks, which seemed to be varied by the position of the patient. There was dulness in the suprapubic region, and no change was produced in this dulness by injections through the catheter. No fracture of the pelvis could be demonstrated even by rectal examination. On account of the great abdominal rigidity and tenderness, with the doubtful movable dulness in the flanks, it was considered wise to explore the abdomen, though the diagnosis of intraperitoneal rupture of the bladder was not definitely made.

A median hypogastric incision was made six hours after the injury. There was blood in the space of Retzius, and on opening the peritoneal cavity a little bloody fluid was found. This came from a rent of the bladder, involving the serous coat only, to the left of the middle of the posterior wall. This area was sutured with a continuous Lembert suture of linen. The lower angle of the peritoneal incision was closed, and a gauze drain from the pelvis was brought out of its upper angle. Then, through the same hypogastric wound, but extraperitoneally, the bladder was detached from the pelvic wall, and liquid blood and clots were evacuated from the extraperitoneal region to the left of and in front of the bladder. No bleeding points could be detected, and no definite rupture of the bladder could be found. Two gauze packs were placed to the oozing area around the triangular ligament and neck of the bladder, both extraperitoneally. The blad-

der was then opened, and bloody urine escaped; the end of the catheter in the urethra could not be felt within the bladder; evidently it had passed into the hæmatoma to the left of the bladder, through a rupture in the neighborhood of the prostatic urethra. The bladder was drained by a rubber tube, through the suprapubic wound, and the middle of the abdominal incision was closed, leaving the peritoneal drain emerging at the upper end and the extraperitoneal and bladder drainage emerging at the lower end. The time of the operation was forty-five minutes.

The patient rallied well from the operation, but died in twenty-four hours with uræmic symptoms (restlessness, delirium, slight dyspnœa, etc.); there were no symptoms of peritonitis. Examination of the wound after death showed no fluid in the peritoneal cavity, no inflammatory lymph, no adhesions, and no injury to any viscera except bladder. There had been no more hemorrhage from the extraperitoneal region where the rupture of the bladder was supposed to be. No fracture of the pelvis was detected.

Dr. Ashhurst said that in order to gain some idea of the mortality and complications of cases of fracture of the pelvis, he had searched the records of the Episcopal Hospital from Jan. 1, 1895, to Dec. 1, 1908. During that period there had been treated in the wards 57 patients with fracture of the pelvis; 18 of these patients died, a mortality of 31.57 per cent. Of these 18 fatal cases, there were no visceral injuries in 8, death in most of these cases being due to other injuries (crushes of the extremities, fractures of the skull, etc.). There were 10 cases complicated by visceral injury, as follows:

	Cases.	Recovered.	Died.
Rupture of the urethra.............	4	1	3
Extraperitoneal rupture of bladder..	4	1	3
Rupture of undiscovered portion of urinary tract	1	0	1
Rupture of liver...................	1	0	1
	10	2	8

In addition to the above cases of extraperitoneal rupture of the bladder, there had been treated 3 other cases (all fatal) without fracture of the pelvis, including the two cases reported by Dr. Ashhurst to-night. Among the entire series of 7 cases of extraperitoneal rupture of the bladder, only one patient recovered (see Case VI in appended list).

As to the relative frequency of intraperitoneal and extraperitoneal ruptures of the bladder, it was generally stated that the latter were much rarer, forming only 10 to 20 per cent. of all cases of rupture of the bladder; and this statement had been made by Dr. Ashhurst himself, in publishing statistics of 110 cases of intraperitoneal rupture of the bladder treated by laparotomy (*Amer. Jour. Med. Sc.*, 1906, ii, 17). But as he had found only 3 cases of intraperitoneal rupture at the Episcopal Hospital, to 7 cases of extraperitoneal rupture, he was inclined to think the rarity of the latter had been overestimated. It must be acknowledged, however, that in many of these, as in most other cases of extraperitoneal rupture reported, no definite rupture had been found, the diagnosis being based on the presence of bloody urine both inside the bladder and in the extraperitoneal pelvic tissues.

In regard to ruptures of the abdominal wall from crushing force, they must be acknowledged to be extremely rare. Besides the case now reported, where there was also fracture of the pelvis, only one other case had been found at the Episcopal Hospital since 1895. This was in a patient of Dr. Neilson's (C. W., 23 yrs., April 24, 1900), who also had extraperitoneal rupture of the bladder, but no fracture of the pelvis. Although the abdominal wall was repaired as well as possible, death occurred the next day.

CASES OF FRACTURE OF PELVIS COMPLICATED BY VISCERAL INJURY.

(Episcopal Hospital, Phila., 1895-1908.)

I. *Fracture of Rami of Pubis and Ischium, Rupture of Urethra.*—Frank D., 29 yrs. Adm. March 26, 1896. Treated by catheterization. Recovered.

II. *Fracture of Pelvis, Fracture of Skull, and Rupture of Urethra.*—John B., 23 yrs. Adm. March 1, 1897. Developed emphysema of abdominal wall, and peritonitis. No operation. Died in 2 days.

III. *Compound Fracture of Ilium and Pubes, Rupture of Urethra.*—Chas. P. M., 22 yrs. Adm. May 24, 1905. Railroad crush. All muscles of thigh and buttocks completely torn out. Bleeding from urethra. Wounds packed. Catheter in urethra. Died in 2 days.

IV. *Fracture of Left Pelvis, Rupture of Urethra, Dislocation of Left Femur, Rupture of Left Lung.*—Frank K., 32 yrs. Adm. May 9, 1907. No operation. Died in 1 day.

V. *Compound Fracture Left Ilium, Extraperitoneal Rupture of Bladder, Rupture of Femoral Vein.*—Alfred M., 25 yrs. Adm. Aug. 27, 1903. Existing wound enlarged by resident, Dr. Havens, femoral vein ligated, extraperitoneal pelvic tissues packed. Died in 2 hours.

VI. *Fracture of Pubic Ramus, Crush of Left Leg, Extraperitoneal Rupture of Bladder.*—James B., 23 yrs. Adm. Oct. 8, 1903. Leg ampu-

tated on admission; bloody urine by catheter, but no other pelvic symptoms. Two weeks later, a fluctuating swelling in left groin was opened by Dr. Hutchinson, urine and blood evacuated from extraperitoneal pelvic tissues, and rupture in anterior wall of bladder found. Bladder drained by tube. Recovered.

VII. *Fracture of Rami of Pubis and Ischium, Both Sides; Extraperitoneal Rupture of Bladder.*—Frank B., 46 yrs. Adm. Sept. 2, 1907. No operation. Died in 4 hours.

VIII. *Fracture of Descending Ramus of Right Pubis, Hæmatoma in Space of Retzius.*—Harry F., 48 yrs. Adm. May 17, 1908. Operation by Dr. Neilson 24 hrs. after injury. Peritoneum opened, intestines punctured for flatus, no obstruction found. Extraperitoneal pelvic tissues packed to control hemorrhage, possibly from obturator artery. Blood in urine; but no definite rupture of bladder found. Died in 7 hours.

IX. *Fracture Near Right Sacro-iliac Joint; Perhaps Rupture of Ureter.* Adam M., 59 yrs. Adm. Aug. 14, 1905. Fell 35 feet. Fluid injected into bladder all recovered. Operation by Dr. Deaver, 7 hours after injury. Free fluid, mostly urine, in peritoneal cavity; no rupture of bladder. Then right lumbar incision, no rupture of kidney found, none could be found in ureter or its pelvis. Packed. Died in 12 hours.

X. *Fracture of Right Pelvis, Rupture of Liver.*—John F. McG., 24 yrs. Adm. March 26, 1906. Symptoms of internal hemorrhage. Patient refused operation for 24 hours. Then operation by Dr. Davis; pint of free blood in peritoneum, large laceration in liver packed; sponged dry. Did well for 2 days, then developed peritonitis, and died on 5th day.

APPARATUS FOR THE CONTINUOUS ADMINISTRATION OF SALINES BY THE RECTUM.

DR. GORDON J. SAXON, by invitation, made a demonstration of an apparatus for the continuous administration of saline by the rectum. For the description of this apparatus see page 404.

DR. A. D. WHITING said there are two or three advantages of this apparatus. One is that the rapidity of the flow can be regulated very readily by means of the pinch-cock. Without the shunt there is no way for the patient to relieve himself of gas, and if the bowel becomes distended by the solution not being absorbed there is bound to be contraction of the muscle and expulsion, if there is not some way by which the solution can flow back. It can readily be seen that this prevents the soaking of the bed. There is always free circulation and the gas can be seen passing into the bottle, and very often colored solution coming back from the rectum. One of the most important things is the tube, which prevents to a great extent the reduction in temperature of the solution. As employed at the Germantown Hospital the temperature of the solution as it enters the rectum has ranged from above 90° to 105° for two or three hours, and the benefit to the patient is much greater than if a cooler salt solution is given.

BOOK REVIEWS.

GENERAL PATHOLOGY. By ERNST ZIEGLER, late Professor of
Pathological Anatomy and of General Pathology in the Uni-
versity of Freiburg, in Breisgau. Translated from the
Eleventh Revised German Edition (Gustav Fischer, Jena,
1905). Edited and brought up to date by ALFRED SCOTT
WARTHIN, Ph.D., M.D., Professor of Pathology and Director
of the Pathological Laboratory in the University of Michi-
gan. With 604 illustrations in black and in colors. William
Wood & Company, New York, 1908.

The present copy of this work is the American translation
of the eleventh edition, which was published by Ernst Ziegler
in 1904; less than a year later, Dr. Ziegler died, so this will be
the latest record which he leaves to the medical profession. His
fame certainly rests more upon his text-book than upon the
results of his investigations, although among these are included
a number of very important contributions. The book itself has
been translated into several languages and has become a familiar,
and in many cases a final, authority that has been referred to
wherever the study of pathology was prosecuted. The ideas
which his work embody form a particularly splendid example of
a scientific text-book as free as possible from subjectivity, one-
sidedness and prejudice. Its influence heretofore upon the more
recent developments of medicine has been very marked, especially
because of the late idea which has been fostered that the publica-
tion of text-books should be discouraged when compared to the
prosecution of research work. Of the intrinsic worth of a volume
such as the one under consideration, there can be no question and
it is particularly fortunate that we have had in the late Dr. Ziegler
a man who has rendered to the world as great a service as if his
efforts had been directed to that of pure investigation, instead of
so wisely sifting the great mass of collected investigations, judging
them as to their worth without prejudice, and bringing from the
chaos a tangible order and scheme.

The last few years have been so replete with new ideas which

have, in many cases, been found to embody important facts, that
it has become almost impossible to review all of the great mass
of literature concerning the new strains of pathogenic micro-
organisms and their effects on the human organisms.   But the
essential facts, and those which represent actual advance in our
knowledge of pathological processes, the author has incorporated
in the contents of this book.   Special mention should be made of
the researches of Shaudinn on the spirochætæ and parasites of
malaria, also of the work done on the trypanosomata, various
pathogenic bacteria, the agglutinins, precipitins, cytolysins, and
the hæmolysins, as well as the numerous investigations and theo-
retic observations that, based upon Ehrlich's side-chain theory,
have been carried out concerning the toxic action of bacterial
products, and the formation of antitoxic and antibacterial
substances.

Of interest, also, at the present time, is the question of tuber-
culosis.   The author's views concerning its etiology and genesis
seem not to have been materially altered, and he concludes that
Koch's view as to the difference between human and bovine
tuberculosis is applicable only in so far as certain differences
in the characteristics of the two strains of bacilli are concerned;
for all these differences, it is true that bovine tuberculosis is com-
municable to man, and that domestic animals may become infected
from tuberculous human beings.   The theory, which seems very
plausible, that infants may be easily infected through milk, has
merely confirmed well-known facts; however, his attempt to
refer all cases of tuberculosis to intestinal infection during infancy,
is hardly tenable.

The recent investigations concerning the etiology, genesis,
and morphology of neoplasms have received analytical consid-
eration, and it is to be noted that their greatest value has been
reached in the researches on the histogenesis of tumors; the
later views of Ribbert and Borrmann that the tumor development
is to be found in the isolation, disconnection and misplacement
of germinal anlage or of single cells during embryonal or extra-
uterine life, together with those of Crompecker that the epithelial
cells can become transformed into connective-tissue cells, have
been discredited by the authors.

Significant advances over the former edition are also noticed
in the theories of fatty degeneration and glycogen deposit.   The

arrangement of the book is left, on the whole, as in the last edition. In the translation, which seems to have taken an exceptional amount of time, the original matter has been given without change or omission.

The progress of pathological knowledge, however, has been so rapid that the American editor has found it absolutely essential, in a great many instances to insert paragraphs and data at the end of the various chapters, in fine print; these addenda are particularly noticeable regarding the recent observations on the effect of Röntgen irradiation, heredity, phagocytosis, opsonins, blood-plates, thrombosis, necrosis, cloudy swelling, fatty degeneration, regeneration, inflammation, malignant neoplasms, tuberculosis, syphilis, relapsing fever, spirochætæ, protozoa, etc., and has thus made the attempt to bring the work up to the date of issue. The styles of the two authors are very distinct, that of the translator, in many cases, tending to theoretical rather than to actual advances. In some instances it is noticed that he has repeated some of Dr. Ziegler's remarks; a case in point may be found by referring to pages 169 and 132. We also note that he does not, in all instances, keep within the province and meaning of the work; for instance, on page 197, we find that he makes a lengthy consideration which is almost entirely in the domain of physiological chemistry. The book in general is merely a compilation of facts; it is in many cases disconnected and does not read easily.

Pre-eminently it is the duty of the pathologist, as teacher, to train the student in habits of medical thought and to show how such data as may be at hand are to be weighed, and what deductions may logically be drawn therefrom, and to put these remarks into such form that the investigator of a particular case may recognize individual symptoms not as isolated facts but as correlated pathological conditions, and thus form a judgment regarding the causation and meaning of the symptom-complex of a case. This one finds very difficult to accomplish from the reading of the work in question. As Bacon says: " *Vere scire est per causas scire,*" which axiom, as far as regards medicine or surgery, can only be gained by the most thorough knowledge of the teaching of our great pathologists, among whom Dr. Ziegler is certainly to be accounted one.

A TEXT-BOOK OF OPERATIVE SURGERY, Covering the Surgical
    Anatomy and Operative Technic Involved in the Operations
    of General Surgery.   By WARREN STONE BICKHAM, Ph.M.,
    M.D., Visiting Surgeon to Charity and Touro Hospitals,
    New Orleans.   Third Revised Edition.   Octavo of 1206
    pages, with 854 illustrations.   W. B. Saunders Company,
    Philadelphia and London, 1908.

In reviewing this, the third edition, of Dr. Bickham's " Text-
book of Operative Surgery," one can not help but remark the
painstaking labor that must have been expended in its prepara-
tion.   The general character of the text is that which has been
used in the preceding edition.

The book is divided as follows,—Part I: Operations of Gen-
eral Surgery.   Part II: Operations of Special Surgery.

The subject is well systematized and arranged in an entirely
original manner.   Preceding each operation, whether in Part I or
Part II, the following scheme is used: (1) Surgical anatomy
of the region or organ; (2) Surface-form and landmarks; (3)
General surgical considerations; (4) Instruments used in the
particular operation; (5) Description of the operation; (6)
Preparation of the patient; (7) Position of the patient, surgeon
and assistant; (8) Landmarks of operation; (9) The incision;
(10) Steps of operation; (11) Comments.   This scheme, as
might be imagined, entails some degree of reiteration where cer-
tain operations resemble each other in their various steps; how-
ever, this is brought to a minimum by a reference to steps in
preceding descriptions.

Critically considered, there are many objections which may
be raised.   In considering the anatomical relations of various
regions, the author introduces an unnecessary amount of text;
this could be obviated by the insertion of a suitable diagram
with a concise description that would give the information desired
much more clearly and more comprehensively to the reader.   A
case in point may be found on page 149, where one finds a particu-
larly dry description of the surgical anatomy of the anterolateral
aspect of the neck.   It is to be noted, also, that while the author
has introduced a large number of illustrations showing the rela-
tions of nerves, arteries and veins, they are not clear, and have to
be studied for some time in order to find out which structure one

is looking at. This might be obviated and, at the same time, give a marked attractiveness to the book, if the artery, vein and nerve were depicted in colors; and there would also be a marked saving in the amount of text used.

The consideration of operations upon the abdominopelvic region is very complete and explicit. It is to be noted, however, that the description of McBurney's intramuscular incision and operation for appendectomy is repeated on pages 807–8 and 900! This is unfortunate and unnecessary. Under the caption of the colostomies, we find the comment that cæcostomy is rarely performed; exception, I think, may be taken to this. The author includes in the same section the description of lumbar colostomy; this has become so obsolete that it might well be omitted with value to the book. In considering excision of the rectum, we find no description of the combined abdominal and sacral routes in conditions where the superior part of the rectum is involved; nor is there any description of excision of the rectum through the vaginal route. Unnecessary space is accorded the subject of cholecystolithotrity; this should be entirely omitted.

The book is well illustrated by accurate and original drawings; the text is clear and succinct. The author, in his comments, might have devoted a little more space to the comparative value of the various operations. The book forms as a whole a most convenient reference for all operative procedures, and represents the most approved surgery and surgical technic of the present day. Any one following Dr. Bickham's technic will start right at any rate, and a careful reading of his admirable descriptions and consideration of their accompanying illustrations will put the operator a long way ahead of the one who takes his initial steps erroneously.

THE POPES AND SCIENCE. By JAMES J. WALSH, M.D., Ph.D., LL.D., Professor of the History of Medicine and of Nervous Diseases at Fordham University School of Medicine; etc. Pages 431. Fordham University Press, New York.

This book is a history of the papal relations to science during the Middle Ages and down to our own time, written from the standpoint of a loyal son of the Church, who has been moved to undertake the task by what he believes to be the misstatements of

many English-speaking historians and, more particularly, as is
evident from the references in the text, of Andrew D. White's
" Warfare of Science with Theology." It is necessarily, there-
fore, controversial in its tone, but nevertheless will richly reward
the reader for the time given to its perusal. *Audi alteram par-
tem* is a good motto for universal adoption. In the heat of con-
troversy, and especially political and religious controversy, erron-
eous and exaggerated statements are inevitable, and such state-
ments by much repetition may become ultimately accepted as
unquestioned truth. Dr. Walsh himself says that in his earlier
professional years he had accepted the general opinion that there
had been many papal documents issued, which, intentionally or
otherwise, hampered the progress of science. His later personal
investigations of the subject had brought him, however, to an
opposite conclusion. The results of his investigations and the con-
clusions to be derived from the facts thus brought out have been
embodied by him in the present volume. He finds that the sup-
posed papal opposition to science was practically all founded on
an exaggeration of the significance of the Galileo incident. As
a matter of fact, the popes were as liberal patrons of science as of
art. In the renaissance period, when their patronage of Raphael
and Michael Angelo, and of other great artists did so much for
art, similar relations to Columbus, Eustachius, Cæsalpinus and
later, to Steno and Malpighi, had like results for science. He
says that for seven centuries the popes selected as their physicians
the greatest scientists of the time, and the list of papal physicians
is the worthiest series of names connected by any bond in the
history of medicine, far surpassing in scientific import even the
roll of the faculty of any medical school. The material bearing
upon this point is now gathered into compact form for the first
time. The author makes out a good case, and one rises from a
perusal of the book with a feeling that the attitude of the Roman
Catholic Church to science was, perhaps, not so bad as it has
been painted. Such had been the conclusion which the reviewer
had come to from his own independent and fragmentary re-
searches. Many things which were incident to the times and were
expressions of the rude and imperfect development of thought
at the period, have been attributed to the Church itself because
the Church was the dominating figure of the period, overlooking
the fact that the Church in its relations to men partook in large

measure of the mental conceptions and social manifestations of each succeeding period, preserving through all, however, an ameliorating and saving influence, so that it has been a marked factor in the progressive betterment of the world. On the other hand, it is not to be denied that in the more recent centuries knowledge has progressed most satisfactorily in those countries which were the freest from the overwhelming dominance of religious dogma.

SURGICAL MEMOIRS AND OTHER ESSAYS. By JAMES G. MUM-FORD, M.D., Instructor in Surgery, Harvard Medical School, etc. Moffat, Yard & Co., New York, 1908. Octavo, pp. 350; numerous illustrations.

This is a book worthy of more than passing notice. It is a series of historical studies, and must tend to help any surgeon who reads it to a wider and more philosophical view of his profession, and make him a better and broader surgeon. More than one-fourth of the volume is made up of a reprint of Dr. Mumford's chapter, " History of Surgery," that appeared as an introduction to Keen's " System of Surgery." Then follows an excellent chapter on " Teachings of the Old Surgeons," in which he shows that some of our surgical fathers did good work, notwithstanding their limitations, an acknowledgment which the surgeons of the present time, in their state of exaltation as to modern achievements and possibilities, are prone to forget. Biographical essays upon Astley Cooper, Benjamin Brodie, John Collins Warren and Jacob Bigelow further pursue the same thought in detailing more at length the characteristics and achievements of these masters in surgery of the past. Very properly the book concludes with an address upon History and Ethics in Medicine, for really the whole book is a contribution to history and ethics. Dr. Mumford's style is pleasing; what he has to say he says in such a way as to attract attention to his thought and to leave a clear impress upon the mind of the reader. The book is entertaining as well as profitable.

CORRESPONDENCE.

INTESTINAL INTUSSUSCEPTION COMPLICATING TYPHOID FEVER.

EDITOR ANNALS OF SURGERY:

In connection with the report in the January number of the ANNALS OF SURGERY of cases of Intussusception Complicating Typhoid Fever, I desire to place on record the following case in my own experience:

A female child, aged eight and a half years, had passed through an attack of typhoid fever of moderate severity. On the morning of April 25, 1907, her temperature was normal; that night, about a half-hour after a bowel movement, she was taken with severe pain in the abdomen, which was referred especially to the right iliac region; there was considerable nausea, slight vomiting, marked collapse, pulse 140, body covered with perspiration. A hypodermic of morphine, with hot applications, relieved the pain and so improved the general symptoms that it was thought best to wait for morning before further intervention. With the morning there was found present slight abdominal distention and pain, but the right rectus was very rigid so that the presence of a perforation was felt to be probable.

She was removed to the Cohoes Hospital where, at 2 P.M., the abdomen was opened. Examination revealed no peritonitis, but an intussusception of the ileum about eight inches from the cæcum; the telescoping was about three-quarters of an inch in extent; this was relieved and the patient went on to uninterrupted recovery, leaving the hospital on the fourteenth day.

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